

# ANNALS of SURGERY

A Monthly Review of  
Surgical Science and Practice

*Edited by*

LEWIS STEPHEN PILCHER, M.D., LL.D., of New York

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Official Publication of the American Surgical Association, of the  
New York Surgical Society and the Philadelphia Academy of Surgery

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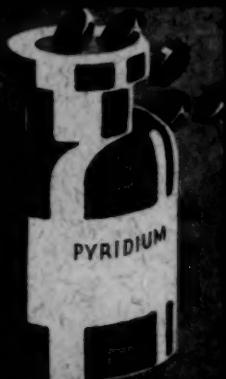
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# ANNALS *of* SURGERY

VOL. XCIV

DECEMBER, 1931

No. 6

## BACTERIAL SYNERGISM IN DISEASE PROCESSES

WITH A CONFIRMATION OF THE SYNERGISTIC BACTERIAL ETIOLOGY OF A  
CERTAIN TYPE OF PROGRESSIVE GANGRENE OF THE  
ABDOMINAL WALL\*

BY FRANK LAMONT MELENEY, M.D.

OF NEW YORK, N. Y.

FROM THE BACTERIOLOGICAL RESEARCH LABORATORY OF THE DEPARTMENT OF SURGERY, COLUMBIA UNIVERSITY, AND  
THE PRESBYTERIAN HOSPITAL OF NEW YORK CITY

SYMBIOSIS has been studied extensively by zoölogists and botanists but it has not been given the attention that it should receive from the medical sciences. The term signifies the living together of two different species either of plants or of animals, or of a plant with an animal. There is fossil evidence that this is a very ancient phenomenon of nature and many believe that it is the most potent factor in the origin of species. Wallin,<sup>1</sup> in his book on symbioticism, uses the term proteotaxis to describe the innate tendency of one organism or cell to react in a definite manner to another organism or cell. This may be positive or negative and positive proteotaxis may result either in parasitism or symbiosis. Parasitism implies some combination in which the parasite benefits while there is either a harmful or an indifferent response on the part of the host. The term symbiosis is applied to those cases in which mutual benefit is derived by the associated organisms. Steche<sup>2</sup> considers that parasitism and symbiosis are similar relationships. In the former, one cell lives at the expense of the other and in the latter there is a balanced condition not injurious to either and usually beneficial to both. Parasitism is a battle, symbiosis an armistice or an alliance. In symbiosis each partner uses the other. It is usually a matter of trade—with each one giving something of no value to itself and receiving something of great value to itself. If at any time one of the partners cannot fulfill the necessities of the other, a parasitic battle ensues which usually results first in the death of the weaker and then in the death of the stronger. Under other conditions parasitic states may gradually change to symbiotic states. On this basis Rheins<sup>3</sup> suggests that in many cases in which individuals have recovered from symptoms of tuberculosis they are really living in symbiotic relationship with the tubercle bacillus. On the other hand, Rheinheimer,<sup>4</sup> while he holds to the importance of symbiosis in the processes of evolution, believes that parasitism and symbiosis are at opposite poles. To quote him:

"The symbiotic relation is characterized by reciprocal differentiations of a progressive order; by due compensation as between the partners; by widely availing usefulness in the web of life. Parasitism, on the other hand, is the denial of such reciprocity, the undoing of its good effects. It is the antithesis of symbiosis, as the facts bear out

\* Read before the New York Surgical Society, May 13, 1931.

abundantly when they are stripped of misleading details. Symbiosis is a good relation; parasitism is an evil one. Good and evil, of course, are relative terms. But once we have a standard by which reliably to judge biological activities and their results, we need not shrink from the attempt to discriminate between legitimate and illegitimate developments, and thus to introduce order into biology in the place of the present chaos and indeterminateness of jargon. The claim made by some that biology is not a matter of values is preposterous. It is a species of scientific fatalism no longer warranted today. The very term 'survival of the fittest' involves a value-judgment. There is no cause for fatalism or pessimism on a due appreciation of symbiosis, no cause to falter and to think that Nature sanctions crime equally with good conduct. True, in the course of evolution, legions of species have strayed from the symbiotic path and have elected instead that of least resistance—that of predacity or of parasitism. But it can be shown that they have declined accordingly, whilst others, which have persisted in a more honest course, have meanwhile gone forward."

On this basis, Rheinheimer offers a new theory of disease concurrently with that of symbiosis. He says: "Disease, degeneration and extinction originate with failure of coöperation, be it between organs or species." Wheeler<sup>5</sup> states in an article on "Social Life Among the Insects" that "Living beings not only struggle and compete with one another for food, mates and safety, but they also work together to insure to one another these same indispensable conditions for development and survival." Hastings<sup>6</sup> says that "Life is not only a struggle for existence among half-starved individuals thirsting for each other's blood but plants and animals of different kinds coöperate to a much larger extent than was formerly supposed."

One of the best examples of symbiotic existence is the lichen. A lichen is formed by the intimate association of a fungus and an alga. They perform an important function in serving as the advance guard of vegetation by reaching out over the desert and into the cold of the north and by climbing mountains to the snow line. They cover bare regions of land and are often followed by other vegetation. Fungi grow around and in the cortical layers of the roots of certain plants and trees. A still more important function is performed by nitrifying bacteria, such as *Bacillus radicola*, which occur in the soil. They enter the root hairs of leguminous plants and grow within the roots, forming nodules. These bacteria take up nitrogen from the air and supply the roots with nitrates, accepting in return carbohydrate for their own nourishment. Bacterial mixtures play an extremely important function in the disintegration of animal bodies. Many other instances of these relationships could be cited but these will serve to indicate the importance of the general laws of symbiosis without which life as it exists on the earth would cease.

Since the early days of bacteriology it has been observed that different species of bacteria frequently exist together but very few reports have been made with regard to the effects that these organisms have on one another. Since the time of Koch<sup>7</sup> much greater importance has been placed upon obtaining organisms in pure culture. Even during the Great War, when wound infections with mixtures of organisms were commonly observed, there is very little evidence in the literature that much thought was given to the symbiosis of these organisms. In the intestine of man and of animals bacteria have

## BACTERIAL SYNERGISM IN DISEASE PROCESSES

symbiotic relationships some of which are mutually beneficial while others are antagonistic. It is still a moot question whether or not this state of affairs is beneficial to the host.

The symbiosis of bacteria has been observed in the laboratory for a long time. Certain species of bacteria completely inhibit the growth of other species. Certain species have an adjuvant action on the growth of other species. Still other species combine and perform certain functions which neither of them can perform alone. This combined activity has been called synergism.

### BACTERIAL SYNERGISM

Most of the observations that have been made with respect to bacterial synergism have been made by chance in the laboratory and have had no clinical importance. Some of these, however, are of considerable importance commercially. Pasteur<sup>8</sup> found that anaerobes could grow in the presence of free oxygen providing that aerobes were present, and he explained this phenomenon by suggesting that the aerobes used up all of the available oxygen. McLeod<sup>9</sup> has tried to explain this symbiotic relationship by demonstrating that the anaerobes are not able to produce peroxidase enough to destroy the peroxides which are formed when growth takes place in the presence of free oxygen, but if aerobes are present they furnish the peroxidase which destroys or neutralizes the peroxide which would otherwise kill the organisms. Herter<sup>10</sup> in his book on the infections of the digestive tract states that were it not for this symbiotic action of anaerobes with aerobes the former could only exist in the large intestine which is without oxygen, for oxygen is present in the small gut. Ward<sup>11</sup> noted that certain fermentations in ginger beer were due to a combination of a yeast with the bacterium. Nencki<sup>12</sup> showed that the bacillus of symptomatic anthrax and a micrococcus together produced butyl alcohol from a fermentable carbohydrate, when neither of them could do it alone. Castellani<sup>13, 14, 15</sup> has been interested in the subject of bacterial synergism for some time. His first observations were made in a study of bakers' yeast in Ceylon. When he separated the many species of organisms in the yeast he found that his pure cultures would not produce gas but when certain combinations were made, gas was formed. Castellani later carried his observations to pathogenic bacteria and found that gas was formed in media containing certain of the complex carbohydrates by the synergism of two species while the pure cultures of the individual organisms failed to produce it. Thus *Bacillus typhosus* with *Bacillus morgani* produced gas with maltose and similar effects were obtained with dysentery bacilli and certain other organisms, which were of differential importance. When these facts had been determined, it was possible by such reactions to determine the carbohydrate present if the organisms were known, or the organisms present if the carbohydrate were known. Castellani agrees with other observers in assuming that in such a symbiosis, one organism initiates the process while the other completes it. In the case of fermentation, he believes that one organism forms acid from the carbohydrate and the other produces gas from the acid. Holman and Meekison<sup>16</sup> made the same observations and came to the same conclusions. They demonstrated that in order to perform this function the two microbes must be actually growing together in intimate association, and that it was not the effect of one bacterium on the other. Sears and Putman<sup>17</sup> went into this matter of gas production a little more fully and found that bacteria could be divided into three groups: the nonfermenters, the acid formers and the gas formers. The nonfermenters never take part in this particular kind of synergism. It is always the result of a combination of an acid former with a gas former. The degradation of the sugar in question is begun by the acid former and in the course of this decomposition substances are formed which are utilizable by the gas formers and gas production results. They repeatedly failed in the attempts to produce gas by inoculating gas-forming organisms into a medium in which an acid former had been grown but which had subsequently been



sterilized either by filtration or heat, so that they believed that the second organism did not act on the end-product of the first but upon some intermediate product. Sherman and Shaw<sup>18</sup> demonstrated the synergism of two organisms in the production of propionic acid. *Bacillus acidi propionici* which is the essential organism for the production of "eyes" and the characteristic flavor of Swiss cheese, will produce a very much larger amount of propionic acid in association with several other organisms than it will alone in a medium containing lactose. The associated organisms may be either lactose fermenters or nonlactose fermenters. Ishikawa<sup>19</sup> made some very interesting observations on the synergistic action of certain bacteria. He combined not two but three different species. He confirmed the findings of others that an acid former and a gas former would together produce gas from a complex carbohydrate but if nitrogenous substances were added to the carbohydrate medium the two organisms which ordinarily, in symbiosis, would break down the carbohydrate to form gas would not do so unless there were present also a proteolytic organism to initiate the breaking down of the proteins present. The products of protein digestion favor the activity of the amylolytic enzymes. Thus, we have a synergistic action which requires the presence of three different kinds of organisms but in this instance the activity of the proteolytic organism takes place *before* and not necessarily *with* the activity of the other organisms. Theobald and Dorothea Smith<sup>20</sup> have shown that just as there is synergism with certain organisms in the production of gas there is a corresponding antagonism with other organisms. They observed that bacteria of the paratyphoid group may be divided into two classes according to the behavior of four-day cultures in lactose bouillon after a second inoculation with certain types of *Bacillus coli*. *Bacillus coli* produces gas after true hog-cholera bacilli have grown in the medium but produces no gas after other paratyphoid bacilli. Likewise Speakman and Phillips<sup>21</sup> found that characteristic production of large amounts of lactic acid by the association of *Bacillus granulobacter-pectinovorum* was prevented by some factor produced in *Bacillus volutans* cultures. *Bacillus granulobacter-pectinovorum* usually carries the fermentation down to acetone and butyl alcohol but it stops with lactic acid if *Bacillus volutans* is present. Burri and Stutzer<sup>22</sup> found that two organisms when combined would produce nitrogen gas from nitrates when neither would do it alone. They showed that one reduced the nitrate to a nitrite and the other produced free nitrogen from the nitrite.

#### BACTERIAL SYNERGISM IN PROCESSES OF DISEASE

There are very few proven instances of disease processes due to the synergism of two species of bacteria. Castellani<sup>15</sup> believes that a good many symptoms in certain diseases which are ascribed to the causative organism are really due to the association of symbiotic organisms. Among these he includes excessive tympanites with typhoid fever. He lists three definite disease entities which are due to the synergistic action of two organisms. *Trichomycosis nigra*, a disease of the hair of the axillary and pubic regions, is caused by a fungus *Nocardia tenuis* and a coccus *Micrococcus nigrescens* neither of which can alone produce the disease. *Trichomycosis rubra* is caused by the same fungus plus a different coccus. *Stomatitis cryptococcus-bacillaris* is a disease of the mouth caused by two organisms, one a fungus and the other a bacillus. Vincent's angina has been considered a disease of symbiotic organisms, a fusobacterium and a spirillum. Some authors have believed them to be morphologic variations of the same organism. Knorr,<sup>23</sup> who has made some interesting laboratory studies with regard to this disease, believes them to be different organisms living in symbiosis, but he has shown that in conjunction with some of the mouth streptococci they perform certain functions which they cannot perform when separated from the streptococci. When cultures are

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made from the mouth under a seal the streptococci predominate at first, then the fusobacteria, then the spirilla and finally the spirochaetes. He believes that this shows that one prepares the ground for the growth of the others and that infection in the mouth with the fusobacterium and spirillum only occurs following a preliminary infection with streptococcus. Roux and Vaillard<sup>24</sup> noted that avirulent tetanus organisms became virulent when mixed with certain other nonpathogenic organisms such as *Bacillus proteus vulgaris*. Novy<sup>25</sup> also noted the enhancement of virulence of his bacterium of malignant oedema when it was mixed with non-pathogenic aërobes. Liermann<sup>26</sup> interested himself in the study of bacterial mixtures in certain putrefactive processes. In one such lesion he found nine different species. When he inoculated pure cultures into animals he obtained no result. Likewise, when he injected mixtures of the organisms he produced no lesion. He then inoculated media containing sterile meat with a mixture of the organisms and injected this culture

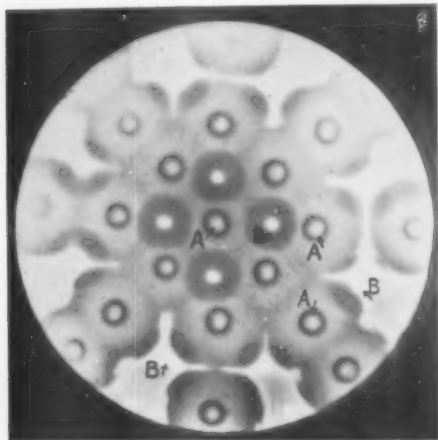


FIG. 1.—Hæmolytic synergism between a double-zoned *Staphylococcus aureus* (A) and a diphtheroid bacillus (B) isolated from a case of chronic empyema. The diphtheroid bacillus colony (B), which is non-hæmolytic, exerts an influence on the partial hæmolysis of the outer zone of the staphylococcus colony (A) which completes the hæmolysis. Print made directly from blood-agar plate.

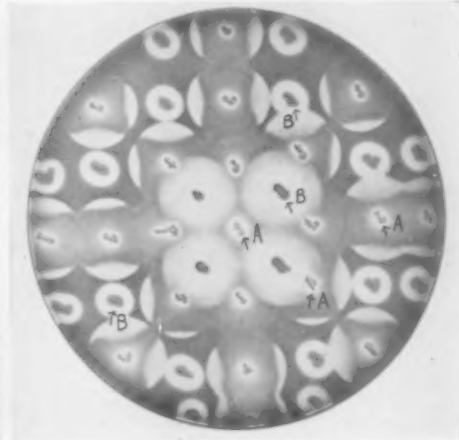


FIG. 2.—Hæmolytic synergism between a hæmolytic *Bacillus welchii* (double zone) and a hæmolytic *Bacillus subtilis*. The outer zone of influence of the *Bacillus subtilis* colony (B) is not visible until it comes in contact with the outer zone of the *Bacillus welchii* colony (A) where it completes the hæmolysis. Photograph of plate (therefore the reverse of Fig. 1).

into animals with resulting death. Here the synergistic action was exerted upon the dead meat and toxic substances were formed which were lethal. Death was not a result of the synergistic action of the organisms on the living animal. Liermann thought that the quantitative relationship of the symbionts was important for the production of the effect but other workers have not agreed that such is the case with respect to other synergistic functions. Bienstock<sup>27</sup> observed that when protein is digested the foulest odor is given off when it reaches a homogeneous mass. This is best accomplished by the combined activity of aërobes and anaërobes. Strict anaërobes are necessary for the ultimate changes but aërobes greatly aid in the early stages of the process. Kämmerer<sup>28</sup> studied intestinal organisms from the viewpoint of urobilin formation, from bilirubin. He found that pure cultures of the different strains

could not produce it alone. Certain mixtures were necessary and it was a true synergistic effect. Kämmerer also studied the production of hæmatoporphyrin from hæmoglobin. He found porphyrin in the fluid from lung abscesses and when he cultured the organisms present he found that they were able to produce hæmatoporphyrin from hæmoglobin only when they were in symbiosis.

Last year I reported to the Society of Experimental Biology and Medicine some striking examples of synergistic action in the production of hæmolysis on blood-agar plates.<sup>29</sup> The phenomenon was noted with three different groups of organisms: a pair of aërobes, a pair of anaërobes and an aërobe with an anaërobe. In the exudate from a case of chronic empyema of tubercular origin, I found among other organisms present, a double-zoned *Staphylococcus aureus* and a diphtheroid bacillus. On blood-agar plates the colony of the double-zoned staphylococcus has a narrow zone of clear hæmolysis immediately around it and a wide zone of partial hæmolysis about 8 to 10 times the diameter of the colony. It so happened that when the colonies were fished from the original blood-agar culture to a fresh plate the diphtheroid bacillus and the double-zoned staphylococcus were streaked side by side. After incubation this plate showed that on the side toward the diphtheroid bacillus the outer zone of the staphylococcus colonies was completely hæmolysed over an area very evidently under the influence of some diffusable substance or physical force emanating from the colonies of the diphtheroid bacillus. Immediately around the diphtheroid colonies no change in the red cells was visible.

In order that this effect might be brought out more clearly a design was made on another plate by alternately dotting with the two cultures. Photographs of those plates show the effect produced by these two organisms when in juxtaposition. (See Fig. 1.) It was found that control nonhæmolytic colonies of several other species did not have this effect but this diphtheroid bacillus had the same effect on the outer zone of both hæmolytic and non-hæmolytic *Bacillus welchii*. If the staphylococcus was planted alone and incubated for twenty-four hours and the bacillus was subsequently planted on the same plate, the same hæmolysis of the outer zone took place. Some months later in culturing a specimen of improperly prepared surgical catgut, two anaërobic organisms were found which had exactly the same relationship to one another. They were a double-zoned hæmolytic strain of *Bacillus welchii* and a non-hæmolytic strain of *Bacillus sordellii*. The plate after anaërobic incubation gave the same appearance as the two aërobic organisms gave before.

Later, a third example of the same phenomenon was observed when, from another specimen of catgut, a hæmolytic strain of *Bacillus welchii* and a hæmolytic strain of *Bacillus subtilis* were found. The *Bacillus subtilis* colony had a narrow zone of clear hæmolysis about it and an outer zone of influence not visible until it came in contact with the outer zone of the hæmolytic *Bacillus welchii* colony which it completely hæmolysed. (See Fig. 2.)

In our recent study of the organisms in raw catgut we found two instances in which a combination of the organisms found in a single specimen of catgut produced a lethal effect when injected into an animal while the





FIG. 3.—A drawing of the lesion in a recent case of progressive gangrene made on the twenty-seventh day after operation and two weeks after the onset of the gangrene. Note the spread in two directions.



## BACTERIAL SYNERGISM IN DISEASE PROCESSES

organisms in pure culture failed to do so. In two other instances abscess and skin necrosis were similarly obtained by bacterial mixtures. In two specimens of improperly sterilized catgut we found a mixture of organisms which had a very prompt lethal effect on laboratory animals when injected together but in pure culture they were entirely nonpathogenic.<sup>30</sup> These combinations will be studied further.

Weinberg<sup>31</sup> has stressed the rôle of bacterial synergism in the etiology of acute appendicitis and has shown that certain combinations of the intestinal organisms are lethal in smaller doses than the pure cultures themselves. Our own experience in our recent studies of peritonitis tends to confirm these findings.

### PROGRESSIVE GANGRENE OF ABDOMINAL WALL

In 1926, Dr. George E. Brewer and the writer<sup>32</sup> reported a case of progressive gangrene of the abdominal wall following the drainage of an appendiceal abscess. The gangrene developed on the tenth post-operative day in the upper half of the wound in the neighborhood of two retention sutures of silkworm gut. The lesion was characterized by an advancing zone of redness and swelling merging centrally into a purplish zone and then frank gangrene of the skin and subcutaneous tissue. The lesion was extremely painful. The gangrene progressed slowly but steadily in spite of conservative methods of treatment which included opening the wound widely, the application of various antiseptics and the local removal of the gangrenous margin. It was only controlled after a very wide excision of the whole lesion, the incision being made in normal skin 3 to 4 centimetres beyond the outer margin of the red zone. A bacteriologic study of the lesion revealed the presence of a microaërophilic nonhaemolytic streptococcus in pure culture in the periphery. This was obtained at first only by anaërobic cultures. In the gangrenous margin this organism was associated with a haemolytic *Staphylococcus aureus* and a diphtheroid bacillus. A series of experiments in animals seemed to indicate that the association of the microaërophilic streptococcus and the *Staphylococcus aureus* was responsible for the lesion and that it was an example of bacterial symbiosis or synergism.

When Doctor Brewer reported this case at a meeting of the American Surgical Association in Detroit in 1926,<sup>33</sup> he described a previous similar case of his own and referred to similar cases reported by Cullen<sup>34</sup> and by Christopher.<sup>35</sup> In the discussion of the case, Porter, Moschowitz, and also Clinton described cases from their own experience which had not been reported. Since that time Alexander,<sup>36</sup> Shipley,<sup>37</sup> Freeman,<sup>38</sup> Mayeda,<sup>39</sup> and Probst and Seelig<sup>40</sup> have described it. In the discussion of Freeman's report, Horsley, Alexander and Ballin referred to cases which they had seen. It may be that the cases reported by Brunsting et al.<sup>41</sup> belong in this group. Altogether, eighteen or more cases of this disease have been reported. In none of the other cases were anaërobic cultures made from the margin of the lesion and the organisms which were reported to have been found in the slough were heterogeneous.



When reference has been made to our report by later authors with the exception of Brunsting<sup>49</sup> some doubt has been expressed with regard to the synergistic bacterial etiology of the disease suggested by our bacteriologic study. Clinically, however, the distinctive cases all behaved in the same way and were characterized by extreme pain and tenderness and a slowly spreading gangrene not yielding to repeated conservative operations but finally yielding to radical and extensive removal of the lesion [except two of the cases, which went on to a fatal termination]. The disease may be said, therefore, to be a definite clinical entity.

## RECENT CASE

In January of this year a man of thirty-five came to the Presbyterian Hospital complaining of a diffuse abdominal pain of two weeks' duration. On examination his abdomen showed slight tenderness over both lower quadrants with a mass that could be felt low down close to the mid-line slightly more on the right than on the left. This was more readily felt by rectal examination. Dr. Richmond Moore, who was on call for emergencies, saw the patient and advised immediate surgical intervention. At operation an abscess was found in the pelvis containing 30 to 40 milliliters of thick, green pus. The coils of the intestines were so matted together that it did not seem wise to explore extensively. The appendix region could not be found and the origin of the abscess could not be determined. The abscess was drained by means of two cigarette drains and a large rubber tube. The peritoneum and the posterior sheath were closed with continuous sutures of chromic catgut. The anterior sheath was sutured with chromic mattress sutures and two silkworm-gut retention sutures were placed in the upper part of the wound. On the day after operation the drains were soaked with exudate from the abscess. Cultures from the exudate yielded *Bacillus coli*, *Bacillus welchii* and a non-hæmolytic microaërophilic streptococcus. On the third day post-operative a note was made on the chart to the effect that the wound was infected. The cigarette drains and the tube were gradually shortened and removed. On the eleventh day post-operative, it was observed that there was infection around the retention sutures and on the thirteenth day it was noted that "the wound had a carbuncular appearance" in the upper half. The retention sutures were removed but the swelling and necrosis continued to spread both right and left from the upper half of the wound. Up to that time the patient had been a jovial, uncomplaining individual, but he then began to complain of intense pain which increased in severity and remained constantly present, aggravated by any movement or any manipulation. His temperature did not rise. His blood count was low but the local gangrenous process continued to spread in both directions in spite of what was thought to be adequate drainage of the margins by the removal of large pieces of necrotic tissue. From day to day pieces of slough were cut away but it continued to spread. On the twenty-seventh day, upon my return from a vacation, I was asked to see the patient. The appearance of the lesion at that time is well shown in Mr. Feinberg's drawing. (See Fig. 3.) The lesion showed such a striking resemblance to the previous case of Doctor Brewer's that the treatment which was successful in that instance was advised, namely, wide excision of the lesion and prompt application of antiseptic fluids. (See Fig. 4.) This resulted in a prompt disappearance of the infection, the denuded area granulated over rapidly and on the eleventh day following this operation, the wound was covered with Thiersch grafts, which took nicely. (See Fig. 5.) Epithelization was complete on the twelfth day, which was twenty-four days after the excision of the lesion and fifty-one days after the original operation.

## BACTERIOLOGICAL STUDY

Needless to say, I was delighted to have the opportunity of studying this interesting lesion again bacteriologically. Inasmuch as the disease had spread

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Fig. 4.—The appearance of the wound on the day after excision.



Fig. 5.—The appearance of the wound one week after Thiersch skin grafting.





FIG. 6.—Pure culture of the microaerophilic nonhemolytic streptococcus from the periphery of the lesion, cultured anaerobically on a blood-agar plate.



FIG. 7.—Mixed culture of the streptococcus and *Staphylococcus aureus* from the gangrenous margin. The plate was incubated for twenty-four hours anaerobically to permit the growth of the streptococcus (pin-point colonies) and then for twenty-four hours aerobically to permit further growth of the staphylococcus (large colonies).



FIG. 8.—Lesion in a dog forty-eight hours after injection. Marked swelling and redness with early gangrene in the centre at the site of injection of 2.5 cubic centimetres of the culture of streptococcus mixed with 2.5 cubic centimetres of the culture of staphylococcus. No swelling on either side at the site of injection of 5 cubic centimetres of pure cultures of the streptococcus (X) and the staphylococcus, (O).



FIG. 9.—The same as Fig. 8 on the fifth day. The gangrenous skin has separated. Undermining and swelling of the surrounding skin persists.



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in two directions, it was possible to study each of these lesions separately. Doctor Moore made an extensive excision of each lesion going approximately 3 to 4 centimetres outside of the zone of redness. Cultures were taken at the incision lines and the excised plaques of skin and subcutaneous tissue were transferred to the laboratory for examination. The deep surfaces were seared as before and bits of tissue taken for culture. In each case the periphery of the lesion yielded the same microaërophilic nonhæmolytic streptococcus in pure culture while the gangrenous portion yielded this organism in conjunction with



FIG. 10.—Another dog on the fourth day after injection in which the mixture (centre) caused an extensive gangrene and the staphylococcus alone produced an abscess (O). The streptococcus alone (X) was without effect.

a faintly hæmolytic *Staphylococcus aureus*. (See Figs. 6 and 7.) *Bacillus welchii* and *Bacillus coli*, which had been present with the streptococcus in the first cultures of the peritoneal fluid, were no longer present in a viable or cultivable state. When the streptococcus and staphylococcus organisms were injected into animals as in the previous experiments, both in pure culture and in symbiosis, it was again found that the gangrenous lesion could be produced only when the two organisms were injected together, for twice the amount of each organism in pure culture failed to call forth the lesion. As with the organisms from Doctor Brewer's case, the streptococcus alone produced prac-

tically no reaction while the staphylococcus caused only a moderate swelling. The lesion in dogs and guinea pigs is shown in Figs. 8, 9, 10, 11 and 12.

Having confirmed to the letter the findings in our previous case, it seemed to be worth while to go farther and try to find out something of the mechanism of the reaction. A microscopic study of the lesion revealed the fact that there was an extensive fragmentation of the dense subcuticular connective tissue and a heavy cellular infiltration of the subcutaneous fat. There was no evidence of a thrombosis of blood-vessels. The vessels were universally dilated and filled with blood with a large number of polymorphonuclear cells clinging to the walls. From a morphologic viewpoint it seemed evident that the gangrene was due to a direct action of some lytic substance on the tissue rather than to a cutting off of the blood supply. Gram stains of the tissue revealed masses of Gram-positive cocci toward the centre of the lesion and scattered organisms in diplo form or in short chains out toward the periphery. No amœbæ were seen such as have been reported in certain somewhat similar ulcerative lesions.<sup>41</sup> These cases were not studied for the presence of anaërobic organisms. It may be that they were of synergistic bacterial etiology and were secondarily contaminated or infected with amœbæ. Dr. F. W. O'Connor of our department of tropical diseases has confirmed the absence of amœbæ in our two cases.

In our study we have attempted to answer the following questions: What was the source of these organisms? Have they any cultural peculiarities or biologic properties which will serve to demonstrate their synergism *in vitro*? Does one organism prepare the ground for the other, or must they work together? Is the gangrene a phenomenon of sensitization? Can the lesion be produced by bacterial filtrates or by the filtrate of one organism acting as an adjuvant to the other organism? Is the combination a specific one or will other combinations produce the same effect? Can a similar effect be produced in certain organs or in the peritoneum as well as in the skin? We have not answered all of these questions but present the results of our study as far as it has gone.

Inasmuch as the streptococcus was found in pure culture in the advancing zone of the lesion in both cases, it seems reasonable to suppose that it is of fundamental importance in the production of this particular lesion, or I might say these particular cases.

The microaërophilic streptococcus is one of a group which occurs frequently in the human intestine and in peritoneal exudates. It is usually missed unless careful anaërobic cultures are made. In a recent bacteriologic study of a series of cases of peritonitis following perforation of the appendix or gut, we found that intestinal streptococci form a large percentage of the bacterial flora of the peritoneal exudates.<sup>42</sup> There are many species and varieties of streptococci in the intestine including the heat-resistant enterococci, the green and also the nonpigment-producing streptococci, true anaërobic streptococci, and a group of microaërophilic streptococci which prefer an anaërobic environment and for the first cultivation must be obtained by anaërobic methods but after several transplantations on artificial media they will grow on the aërobic plates as well. From our peritoneal exudates we cultivated these organisms many times and Weinberg

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and his co-workers<sup>41</sup> found them in the contents of acutely inflamed appendices. Several classifications of intestinal streptococci have been made recently: for example, those by Alston<sup>42</sup>, and by Welch<sup>43</sup>, and also by Dible<sup>44</sup>, which have not taken into account either these organisms or the strictly anaërobic streptococci. Tissier<sup>45</sup> isolated an anaërobic streptococcus from a stool of a man with a putrid enteritis. The anaërobic streptococci of gunshot wounds so frequently reported during the War were presumably of intestinal origin. Prevot<sup>47</sup> has given one of the best summaries of the anaërobic streptococci analyzing the reports of previous workers and adding his own experiences. He studied twenty-seven strains which he obtained from patients. There were twelve cases of lung abscess, five of bronchiectasis, eight puerperal infections and two cases of appendicitis. He divided them into three groups. The first formed gas and produced a putrid odor. Of these he had seven strains. The second group were non-gas-forming and nonfetid, of which he had six strains. The third group he called "anaërobies de predilection" of which he had fourteen strains. The first two groups are strict anaërobes and the last are anaërobic on initial cultivation but after a number of artificial transplantations acquire the ability to grow aërobically. Because of this adaptability this group has been given the name of *Streptococcus evolutus*. It occurred in all of the above-mentioned pathologic conditions. The organisms which we have found in both of these cases evidently fall into this group. They correspond to Prevot's description. This organism was observed by Graf and Wittneben in 1907.<sup>48</sup> Prevot described its cultural characteristics. He also stated that "most of the strains show no pathogenicity but a few will produce slight swelling when injected under the skin of guinea pigs and rabbits and occasionally produce pus so that we must consider it as a pyogenic organism. Agglutinating antiserum may be produced and such a serum will agglutinate other strains of this group but not strictly anaërobic streptococci." Prevot did not mention the possible significance of this organism in symbiosis.

In Doctor Moore's case and in Doctor Brewer's case the streptococcus probably came from the intestine, entered the peritoneum with a perforation of the appendix and contaminated the wound of the abdominal wall at the time of operation. In neither case was the *Staphylococcus aureus* there in the first cultures. It is seldom found in peritoneal exudates. It was probably introduced either at the time of operation or afterward, possibly dropping from the air onto the sterile field in the operating room. It is frequently found in wound infections following clean operations. The rarity of the gangrenous lesion among so many drained cases of peritonitis is probably due to the necessity for the coincidence of these two organisms. The tension of the silkworm-gut retention sutures may have played a part in the establishment of the infection.

We tested the fermentation reactions of these organisms in pure culture and in symbiosis but were not able to determine any function of the pair not performed by one of them. The streptococcus fermented dextrose, lactose, saccharose and salicin but not mannite. The staphylococcus fermented the first three and mannite but not salicin. Both are acid formers and neither is a gas former. The effect on gelatin, milk and Loeffler's coagulated blood serum likewise showed no synergistic action. Both liquefied gelatin and coagulated milk with a retraction of the clot. Loeffler's serum was not liquefied. Digestion of protein, fat and carbohydrate similarly failed to point the way to any synergistic enzyme action as far as our limited tests were concerned. We found that the lesion could be produced only when the organisms were injected together—either having grown together overnight or having

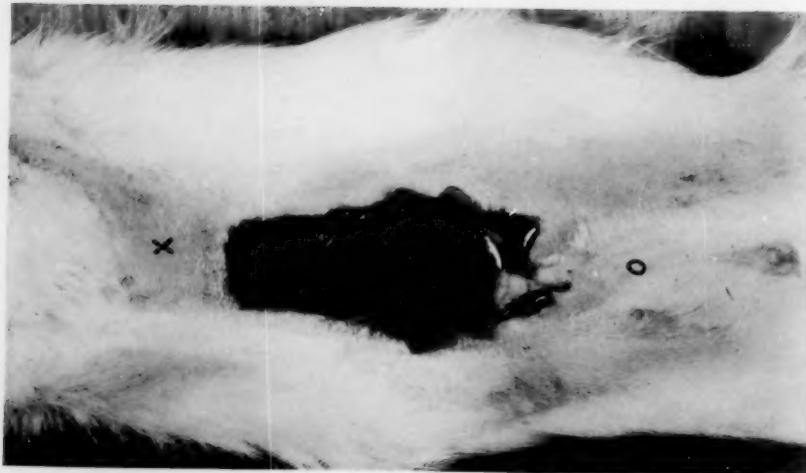


FIG. 11.—The lesion in a guinea pig. Anteriorly (at X) 2 cubic centimetres of streptococcus culture were injected. Posteriorly (at O) 2 cubic centimetres of staphylococcus were injected without effect. In the centre 1 cubic centimetre of each was injected with extensive gangrene. The slough has separated—sixth day.

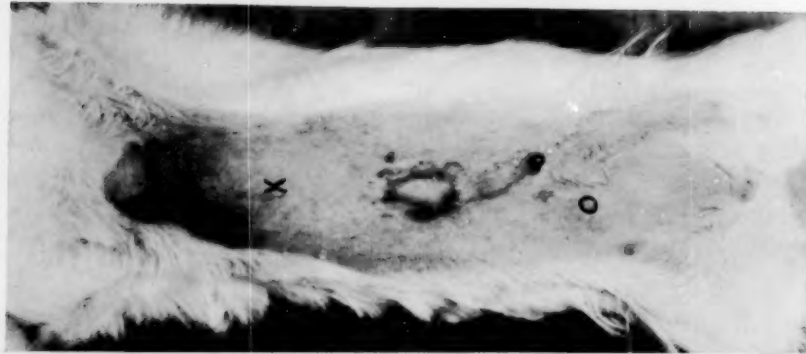


FIG. 12.—The lesion in a guinea pig with the streptococcus and a control staphylococcus—the same amounts of culture as indicated in Fig. 11.



FIG. 13.—The lesion in a guinea pig with the area of the staphylococcus injection (O) approximating the area of the mixed-culture injection. In this region there is a semilunar area of necrosis. The area of streptococcus injection (X) is unaffected.

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been mixed together just before injection. If they were injected separately even in close juxtaposition the association was not close enough and sufficient mingling did not take place to produce the lesion. If one organism was injected alone and the other organism was injected at the same site on the next day we could never produce the lesion. Whether this was due to the fact that a large proportion of the original injection had been removed or a protective mechanism had been called forth by the first injection to withstand the onslaught of the combination we have not yet determined. It cannot be said, therefore, that one organism prepares the ground for the other to produce the gangrenous effect.

Filtrates from these organisms did not produce this lesion even when a few organisms are present, as in the centrifuged supernatant fluids of cultures

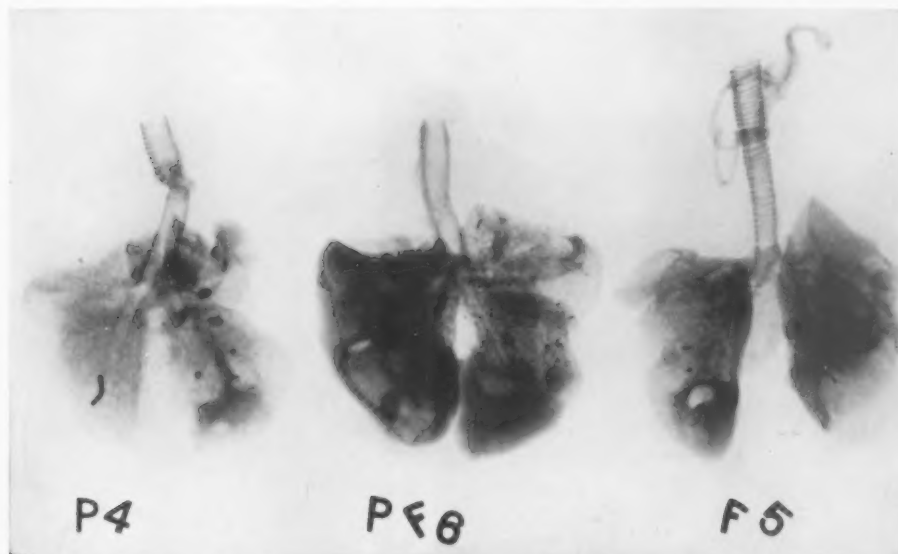


FIG. 14.—X-ray pictures of the lungs of the rabbits (after removal) into which the infected barium and agar emboli were injected twenty-five days previously: P—*Streptococcus* alone—very small lesion in one lung. F—*Staphylococcus* alone—moderate lesions in both lungs. PF—Symbiosis with half the dose of each organism—extensive lesions in both lungs.

and the filtrate of one with the whole culture of the other did not produce gangrene although the swelling was somewhat more pronounced than with the pure culture alone.

Certain other staphylococci with the streptococcus will sometimes produce the lesion so that the staphylococcus is not specific. (See Fig. 12.) None of the control staphylococci, however, produced as extensive a lesion as the organism cultured from the patient in question. When the lesion is produced by injecting a combination of the two organisms and the control injections of the pure cultures are in close proximity, the margin of the area receiving the staphylococcus injection toward the central lesion will take on the gangrenous appearance but the corresponding margin of the area receiving the streptococcus will not be affected. It may be that in the combined lesion the strepto-



cocci spread more widely than the staphylococci and reach the site of the staphylococcus injection in sufficient concentration to produce the lesion. Or it may be that it takes a smaller dose of the streptococcus to activate the staphylococcus than *vice versa*. This effect is shown in Fig. 13.

When doses which are adequate to produce the lesion in the skin were injected into the peritoneum of guinea pigs, there was no evidence of disease. The peritoneum was able to take care of large numbers of bacteria in a free broth culture but when the culture was incorporated with barium in a cylinder of agar, the combination of the streptococcus and staphylococcus caused a progressive loss of weight, resulting in death in four days. The staphylococcus alone with a double dose resulted in death two days after the combination but without showing any illness the day before death. The streptococcus alone produced no ill effects whatsoever.

The fact that this type of streptococcus is so frequently found in lung abscesses led us to attempt to produce this lesion in animals. A suspension of equal parts of barium sulphate and 2 per cent. melted agar was sterilized by boiling and then cooled to 40° C. This suspension was poured into three small bottles and the cultures of streptococcus and staphylococcus were then added separately and together. The mixture of staphylococcus and streptococcus contained half of the number of each organism which was used in the pure cultures. After thoroughly mixing the cultures with the barium and agar it was allowed to solidify. With a large syringe needle a cylinder was then cut about 25 millimetres in length and 1.5 millimetres in diameter. To ascertain its presence in the needle, it was first expelled into a sterile dish and then sucked up into the needle again. With a small amount of saline in the syringe these plugs were then injected into the jugular veins of three rabbits. X-rays showed that although they broke up to some extent in passing through the heart they generally were caught in one or both lower lobes. X-rays of the lungs were then taken at intervals of two to three days. Five days after injection, the rabbit which received the mixture of organisms began to lose weight and the X-ray film showed an infiltration of the lungs around the infected emboli. This rabbit continued to lose weight while the others appeared normal. Later X-rays showed progression of the lesion in both lungs. After fifteen days, however, the X-ray of the rabbit receiving staphylococcus alone showed infiltration around the emboli. The animals were then sacrificed and the lungs were removed. All three showed adhesions of the lung to the diaphragm in the region of the emboli. The streptococcus embolus produced only an infarct. The staphylococcus alone produced a pneumonitis involving the lower third of both lungs. The combination of organisms resulted in a much more extensive involvement—at least three-quarters of both lungs being consolidated. This study will be carried further but these experiments suggest that in the lungs also these organisms have some adjuvant action upon one another.

#### DISCUSSION

In connection with the two cases of progressive gangrene of the abdominal wall, these points should be emphasized: Both occurred following

the drainage of a peritoneal abscess, presumably of appendiceal origin. In both, the streptococcus was present in the first cultures. In both cases the peritoneal infection took care of itself. In both the gangrene developed in the region of silkworm-gut retention sutures. Both complained bitterly of the pain associated with the lesion. In both, conservative treatment failed to check the progress of the disease. Both recovered promptly after the wide excision of the lesion. In both instances the microaërophilic streptococcus (anaërobic by preference) was found in pure culture far out in relatively normal tissues and in the red zone beyond the gangrene. In both cases the gangrenous tissue contained both the streptococcus and the staphylococcus. Practically identical results were obtained when the organisms from these two cases were injected into experimental animals. These facts would seem to indicate that these organisms were responsible for the lesion and suggest that in similar cases they may be found again. It is hoped that attempts will be made to confirm these findings in other cases.

These facts also indicate the importance of making anaërobic cultures in all cases with peritoneal exudate. If seemingly anaërobic streptococci are found, this lesion should be watched for. It is possible that the organisms would not have gained a foothold in the wound, if it had not been partially closed with retention sutures at the original operation. The possibility of the development of this type of infection must be considered another reason why the skin and subcutaneous tissues should be left widely open after drainage of an intraperitoneal abscess. If such a lesion develops, wide excision is indicated to bring about prompt relief and to prevent further destruction of the abdominal wall.

The fact that these organisms have an adjuvant action upon one another seems to be confirmed by the animal experiments. The nature of this phenomenon has not been clearly shown and will have to await further experimentation. The results of our study so far seem to indicate that one organism does not initiate a process which the other completes at a later time as is the case with a combination of proteolytic and saccharolytic organisms. Our study indicates rather that it is necessary for them to be growing together intimately and that the product which is the cause of the gangrene is made by the action of one organism on some intermediate product of metabolism produced by the other, as is the case with certain combinations of fermentative bacteria.

Hæmolytic synergism as illustrated by the two organisms isolated from the case of chronic empyema may have been of minor significance in the illness from which the patient suffered but its occurrence is suggestive of the possibility of the synergistic effects of mixed infections which are not so obviously demonstrated.

The lethal action in laboratory animals of mixed cultures found in raw and insufficiently sterilized catgut, which could not be duplicated by pure cultures of those organisms, indicates clearly that we must not be content merely with the destruction of the so-called pathogenic bacteria in catgut, but all species without regard to their intrinsic pathogenicity. In such toxins we may find the

explanation of the profound toxæmia of some cases of intestinal obstruction and certain cases of peritonitis which toxæmia may be absent in other cases, apparently similarly obstructed or with an equally extensive peritonitis.

The production of a skin lesion with doses which are well tolerated by the peritoneum may be explained by the relative speed of absorption from those two tissues or a special predilection of the staphylococcus and streptococcus for the skin and subcutaneous tissues. The production of disease within the peritoneum with much smaller doses when contained in an agar plug is consistent with the former hypothesis.

The production of hæmatoporphyrin in lung abscesses and urobilin in the intestine by the combined action of bacteria are again indices of other possible reactions which cannot be so easily demonstrated but which may be much more significant as factors in disease.

When two or more organisms are associated in the production of a disease process in man, they are in symbiosis with one another but are parasitic with respect to the man. The fact that they produce the disease in combination when they cannot do it alone suggests that their association is of mutual benefit to them while it is harmful to the common host.

Clinically it has been observed repeatedly that mixed infections are usually worse than infections with a single species, for example—tendon-sheath infections with streptococcus and staphylococcus and tuberculosis with pyogenic empyema, arthritis or lymphadenitis. We recently observed in our post-operative wound infections following clean operations that the majority of serious infections yielded more than one species of organism while the majority of trivial cases yielded a single organism. Human bites frequently produce alarming and serious infections when the only organisms which can be obtained on culture are nonpathogenic in pure culture. The complications of measles and whooping cough with their "secondary invasion" of other organisms (particularly streptococci) might well be studied from a symbiotic viewpoint. These clinical observations have been common but very little study has been made to determine whether they represent a summation of effects or synergistic phenomena.

#### SUMMARY

We have tried to emphasize the importance of symbiosis in various processes of life.

We have given some illustrations of the synergistic action of bacteria in certain *in vitro* experiments in the laboratory which may have no clinical significance but which indicate the possibility of other synergistic effects which may not be so easily demonstrated but which are significant in disease processes.

We have reviewed the synergistic diseases and the disease processes which have been observed by other authors and have added certain observations of our own, namely:

(1) The hæmolytic synergism of two organisms found in the exudate in a case of chronic empyema.

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(2) The lethal effect in experimental animals of a mixed culture of organisms found in unsterile catgut which could not be produced by the same organisms in pure culture.

(3) The adjuvant action of organisms found in cases of peritonitis demonstrated by the production of death with small fractions of minimal lethal doses of these organisms when injected together.

(4) The almost exact duplication of bacteriologic findings in two cases of progressive gangrene of the abdominal wall following the drainage of a peritoneal abscess. These cases both yielded a microaërophilic streptococcus and a *Staphylococcus aureus* capable of producing a gangrene of the skin and subcutaneous tissues, when injected together into experimental animals, while the pure cultures failed to produce the lesion.

(5) The adjuvant action of these same organisms when injected into the peritoneum and lung under certain conditions.

### CONCLUSIONS

Certain bacteria have a synergistic function in the production of certain types of disease or symptoms of disease.

This synergistic action should always be kept in mind in studying disease processes involving tissues, organs, or systems in which mixtures of organisms are frequently or occasionally found.

### BIBLIOGRAPHY

- <sup>1</sup> Wallin, Ivan E.: Symbioticism and the Origin of Species. Symbioticism, chap. V, p. 171, Williams and Wilkins Co., Baltimore, 1927.
- <sup>2</sup> Steche, O.: Parasitismus und Symbiose. Handb. d. norm. u. path. Physiol., vol. i, pp. 628-692, 1927.
- <sup>3</sup> Rheins: Hat der Tuberkelbazillus eine Lebensgemeinschaft mit dem Menschen? München. med. Wchnschr., vol. lxxii, pp. 941-942, 1925.
- <sup>4</sup> Rheinheimer, H.: Symbiosis and Evolution. Jour. Ment. Sc., vol. lxi, pp. 339-348, 1923.
- <sup>5</sup> Wheeler, W. M.: Social Life Among the Insects. Scientific Monthly, vol. xiv, pp. 497-524, 1922.
- <sup>6</sup> Hastings, S.: Team-work in Nature. Lancet, vol. ii, pp. 774-777, 1923.
- <sup>7</sup> Koch, R.: On the Investigation of Pathogenic Microorganisms. Mitt. a. d. k. Gesundheitsamte, vol. i, 1881.
- <sup>8</sup> Pasteur, L.: Animalcules infusoires vivants sans gaz oxygène libre et déterminants des fermentations. Compt. Rend. de l'Acad. des Sci., vol. lii, p. 344, 1861.  
*Idem*: Physiologie végétale. Expérience et vues nouvelles sur la nature des Fermentation, vol. lii, p. 1260, 1861.
- <sup>9</sup> McLeod, J. W., and Gordon, J.: The Problem of Intolerance of Oxygen by Anaërobic Bacteria. Jour. Path. and Bact., vol. xxvi, pp. 332-343, 1923.
- <sup>10</sup> Herter, C. A.: Infections of the Digestive Tract, pp. 360; The Macmillan Co., New York, p. 28, 1907.
- <sup>11</sup> Ward, H. M.: The Ginger Beer Plant, and the Organisms Composing It; a Contribution to the Study of Fermentation Yeasts and Bacteria. Phil. Tr. Roy. Soc., vol. clxxxiii B, pp. 125-197, London, 1893.
- <sup>12</sup> Nencki, M.: Über Mischkulturen. Centralb. f. Bakt. I. O., vol. xi, pp. 225-228, 1892.
- <sup>13</sup> Castellani, A.: Fermentation Phenomena when Different Species of Microorganisms are in Close Association. Proc. Soc. Exper. Biol. and Med., vol. xxiii, pp. 481-488, 1926.

- <sup>14</sup> Castellani, A.: Importance of Symbiosis, or Close Association of Different Species of Organism in Production of Certain Diseases and Certain Symptoms of Disease. *J. A. M. A.*, vol. lxxxvii, pp. 15-22, 1926; also *Jour. Trop. Med.*, vol. xxix, pp. 217-226, 1926.
- <sup>15</sup> Castellani, A.: "Symbiotic Fermentation Phenomenon" and Its Use in Differentiation of Certain Microorganisms and in Identification of Certain Carbon Compounds. *Ann. de l'Inst. Pasteur.*, vol. xlii, pp. 461-474, 1928.
- <sup>16</sup> Holman, W. L., and Meekison, D. W.: Gas Production by Bacterial Synergism. *Jour. Inf. Dis.*, vol. xxxix, pp. 145-172, 1926.
- <sup>17</sup> Sears, H. J., and Putman, J. J.: Gas Production by Bacteria in Symbiosis. *Jour. Inf. Dis.*, vol. xxxii, pp. 270-279, 1923.
- <sup>18</sup> Sherman, J. M., and Shaw, R. H.: Associative Bacterial Action in the Propionic Acid Fermentation. *Jour. Gen'l. Physiol.*, vol. iii, pp. 657-658, 1920.
- <sup>19</sup> Ishikawa, M.: Gas Production by Bacterial Symbiosis with Special Reference to Influence of Nitrogenous Substances. *J. Inf. Dis.*, vol. xli, pp. 238-256, 1927.
- <sup>20</sup> Smith, T., and Smith, D.: Inhibitory Action of Paratyphoid Bacilli on the Fermentation of Lactose by *Bacillus Coli* I. *J. Gen'l. Physiol.*, vol. iii, pp. 21-33, 1920.
- <sup>21</sup> Speakman, H. B., and Phillips, J. F.: A Study of a Bacterial Association. 1. The Biochemistry of the Production of Lactic Acid. *Jour. of Bact.*, vol. ix, pp. 183-197, 1924.
- <sup>22</sup> Burri, R., and Stutzer, A.: Ueber einen interessanten Fall einer Mischkultur. *Cent. f. Bakt.*, vol. xvi, pp. 814-817, 1894.
- <sup>23</sup> Knorr, M.: Ueber die fusospirillare Symbiose, die Gattung *Fusobacterium* und *Spirillum sputigenum*. *Cent. f. Bakt.*, vol. lxxxvii, 1 orig.; pp. 536-545, 1922.
- <sup>24</sup> Roux, E. and Vaillard, L.: Contribution à L'Étude du Tétanos. *Ann. de l'Inst. Pasteur*, vol. vii, pp. 65-140, 1893.
- <sup>25</sup> Novy, F. G.: Ein neuer anaerober *Bacillus* des Malignen Oedems. *Zeit. fur. Hyg. und Inf.*, vol. xvii, pp. 209-232, 1894.
- <sup>26</sup> Liermann, W.: Bakteriologische Untersuchungen über putride Intoxication. *Centralblatt fur Bakteriologie.*, vol. viii, pp. 364-365, 1890.
- <sup>27</sup> Bienstock: Untersuchungen über die Actiologie der Eiweissfäulnis. *Arch. f. Hyg.*, vol. xxxvi, pp. 335-389, 1899.
- <sup>28</sup> Kämmerer, H.: Beiträge zur Bedeutung des Bakteriellen Synergismus für die Biologie. *Klin. Wchsch.*, vol. iii, pp. 723-727, 1924.
- <sup>29</sup> Meloney, F. L.: Aërobic and Anaërobic Examples of Hæmolytic Bacterial Synergism. *Pro. Soc. Exper. Biol. and Med.*, vol. xxvi, pp. 205-206, 1928.
- <sup>30</sup> Meloney, F. L., and Chatfield, M.: How Can We Insure the Sterility of Catgut? *Surg., Gynec., and Obst.*, vol. I, pp. 271-277, 1930.  
*Idem*: The Sterility of Catgut in Relation to Hospital Infections. *Idem*, vol. lii, pp. 430-441, 1931.
- <sup>31</sup> Weinberg, M., Prevot, A. R., Davesne, J., and Renard, C.: Recherches sur la bactériologie et la sérothérapie des Appendicites aiguës. *Ann. de l'Inst. Pasteur*, vol. xlii, pp. 1167-1241, 1928.
- <sup>32</sup> Brewer, G. E., and Meloney, F. L.: Progressive Gangrenous Infection of the Skin and Subcutaneous Tissues, Following Operation for Acute Perforated Appendicitis: A Study in Symbiosis. *ANNALS OF SURGERY*, vol. lxxxiv, pp. 438-450, 1926.
- <sup>33</sup> Brewer, G. E., and Meloney, F. L.: Progressive Gangrenous Infection of the Skin and Subcutaneous Tissues, Following Operation for Acute Perforated Appendicitis: A Study in Symbiosis. *Trans. of Amer. Surg. Assoc.*, vol. xlv, pp. 389-410, 1926.
- <sup>34</sup> Cullen, Thomas S.: A Progressive Enlarging Ulcer of the Abdominal Wall Involving the Skin and Fat, Following Drainage of an Abdominal Abscess, Apparently of Appendiceal Origin. *Surg., Gynec., and Obst.*, vol. xxxviii, pp. 579-582, 1924.



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- <sup>35</sup> Christopher, F.: Severe Spreading Carbuncular Infection of Chest-Wall Following Rib Resection under Local Anæsthesia. *Surg. Clinics of N. A.*, vol. iv, pp. 795-810, 1924.
- <sup>36</sup> Alexander, E. G.: Post-operative Spreading—Superficial Gangrene. *ANNALS OF SURGERY*, vol. lxxxiv, pp. 461-463, 1926.
- <sup>37</sup> Shipley, A. M.: Progressive Gangrenous Ulceration of the Abdominal Wall. *ANNALS OF SURGERY*, vol. lxxxvii, pp. 245-249, 1928.
- <sup>38</sup> Freeman, L.: Progressive Gangrene, Painful Ulceration of the Abdominal Skin and Subcutaneous Tissues Following Operation. *ANNALS OF SURGERY*, vol. xcii, pp. 779-785, 1930.
- <sup>39</sup> Mayeda: Eine seltsame Hautgeschwürsbildung nach der Appendektomie. *Deut. Zeit. für Chirurgie*, vol. cxcix, pp. 350-353, 1927.
- <sup>40</sup> Probst, J. G., and Seelig, M. G.: The Treatment of Post-operative Progressive Gangrenous Infection of the Skin and Subcutaneous Tissue with Blood from Immunized Donors. *Surg., Gynec., and Obst.*, vol. xlvii, pp. 247-251, 1928.
- <sup>41</sup> Engman, M. F. Jr. and Meleney, H. E.: Two cases of Amoebiasis Cutis (*Entamoeba histolytica*). *Arch. Derm. and Syph.* In press 1931. Cole, W. H. and Heideman, M. L.: Amoebic ulcer of the abdominal wall following appendectomy with drainage. *Jour. Amer. Med. Asso.*, vol. xcii, pp. 537-540, 1929.
- <sup>42</sup> Meleney, F. L.: Harvey, H. D.; Jern, H. Z.: Peritonitis. 1. The Correlation of the Bacteriology of the Peritoneal Exudate and the Clinical Course of the Disease in 106 Cases of Peritonitis. *Arch. of Surg.*, vol. xxii, pp. 1-66, 1931.
- <sup>43</sup> Alston, J. M.: The Investigation of Streptococci Isolated from the Alimentary Tract of Man and Certain Animals. *Jour. Bact.*, vol. xvi, pp. 397-407, 1928.
- <sup>44</sup> Welch, H.: Classification of Streptococci of Human Feces. *Jour. Bact.*, vol. xvii, pp. 413-421, 1929.
- <sup>45</sup> Dible, J. H.: Enterococcus and Fecal Streptococci; Their Properties and Relations. *J. Path. and Bact.*, vol. xxiv, pp. 3-35, 1921.
- <sup>46</sup> Tissier, H.: Coccus anaérobie des selles de l'homme. *Compt. rend. Soc. de biol.*, vol. xciv, pp. 447-448, 1926.
- <sup>47</sup> Prevot, A. R.: Les streptocoques anaérobies. *Ann. de l'Inst. Pasteur*, vol. xxxix, pp. 417-447, 1925.
- <sup>48</sup> Graf, H., and Wittneben, W.: Zwei durch anaerobes Wachstum ausgezeichnete Streptokokken. *Cent. f. Bakt.*, vol. xlv, orig., pp. 97-110, 1907.
- <sup>49</sup> Brunsting, L. A., Goeckerman, W. H., and O'Leary, P. A.: Pyoderma (Echthyma) Gangrenosum. Clinical and experimental observations in five cases occurring in adults. *Arch. Derm. and Syph.*, vol. xxii, pp. 655-680, 1930.

## SPINA BIFIDA

A CLINICAL STUDY WITH A REPORT OF TWELVE PERSONAL CASES

By WILLIAM T. COUGHLIN, M.D.

OF ST. LOUIS, MO.

THE successful repair of any serious congenital defect in the new-born ordinarily carries with it its own reward. To feel that one has overcome a defect of nature on behalf of an unfortunate infant should beget a gratifying self-satisfaction. With regard to most of the operable congenital defects this is true, but in the case of spina bifida, my personal experience has not always been entirely satisfactory. Although the operations have all been technically successful, there are some among those patients who, it seems to me now, would have been better left unoperated upon. That a single case of paralysis of bladder and rectum in the new-born, associated with myelocoele of any variety, has ever been cured by operation is not likely. A somewhat extensive reading of the literature has only strengthened this opinion. And since it is highly probable that all such paralyzes are due to defective cord development, any cure by operation is not likely in future. Therefore, the author, with regard to these babies, like the first surgeon pioneers in this field, von Recklinghausen and Hildebrand, feels that it is better to leave them unoperated upon.

The incidence of spina bifida is usually placed at about one in each thousand births. Harrar, in 1916, found fifty-nine cases in 91,600 at the New York Lying-in Hospital. The report of the London Clinical Society's Committee for the study of spina bifida in 1885 gives twenty-two in 22,293 births at the Paris Maternité. In an examination of pathologic embryos, Mall found it twelve times in 163 and Panum thirty-eight in 404. From this Mall deduces that for each case which goes to term at least five are aborted.

The condition is said to have been named by Tulpus (Ranke) in 1641, but it was not until the early years of last century that it became of much scientific interest. The younger Saint-Hilaire, in 1832, described it and refers to the various types, even the rare anterior variety and the syringo-myelocoele. In fact, he insists that the name spina bifida can be *correctly* applied only to those of the anterior variety. The name "fissure spinale" he gave to the usual varieties. He refers to it as an arrest of development similar to anencephalus, describes the usual accompanying deformities and discusses the different varieties and their most common sites. Cruveilhier (1849) refers to it as "une hernie aqueuse" sometimes containing the cord in the sac. He asserted it was *not* due to hydrocephalus, which it often accompanied; they were both due to a common cause—"hydropsie." Förster (1861) made certain observations, and Rindfleisch (1863) discusses the condition, especially the anterior variety. He argued that this was a consequence of the failure of

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the arches to unite and due to muscle pull. Ranke (1878) treated the subject at length. He deplored the fact that his colleagues had failed to give proper credit to the French and especially to Cruveilhier. Ecker, in 1880, studied a four-millimetre embryo with a wide-open sulcus. Tourneux and Martin (1881) published a microscopic study of ten cases (one an embryo of eight millimetres). They described sub-arachnoid pockets and the relations of the spinal ganglia, and traced the cord to the roof of the sac. They credit Bevalet (1857) with the observation of the transverse arrangement of the nerves of the cauda when this region is affected. Cleland (1883) gives a quite detailed study of nine specimens. The interest in the subject in England led to the appointment of a commission for its study by the London Clinical Society in 1882. This commission made its report in 1885, and that year also there appeared a lecture by Humphrey—illustrated with specimens from the Hunterian Museum. On reading this one feels that with regard to its pathology, all that has been added since is the nomenclature, and this was given us by von Recklinghausen (1886).

As to the particular cause of the condition, we are still ignorant. Panum (1878), Dareste and Féré (1893), and Morgan (1909), by variations of temperature, trauma, chemicals or position, produced certain deformities in chicks, among others, spina bifida. Mall was of the opinion some malformations were hereditary and others produced in a mechanical way, and Baldwin (1915) claimed to be able to produce spina bifida at will by the use of the violet ray. On reading the article, I think it is a bifurcation of the spine rather than the surgical condition known as spina bifida he has so produced.

Ranson makes the statement that the neural groove is the most conspicuous part of a 2.4-millimetre embryo, and the following facts seem to have been agreed upon by embryologists for so long they are no longer questioned. The neural groove closes by the approximation of its walls—all but its very bottom is thus obliterated. This part becomes an epithelium-lined tube and from it is developed the central nervous system. The closure of the tube begins in the cervico-dorsal region and progresses caudad and cephalad. By the end of the third week the groove has disappeared, but two openings—the neuropore towards the cephalic end, and the caudopore towards the caudal end—remain open for some time longer. The vertebral arches should unite and form a canal for the cord by the end of the eleventh week. Until the end of the third month, cord and spinal column are equal in length and rate of growth. From this time on the column lengthens faster than the cord. The anterior ends of the cord and spine being fixed at the head level, the lower end of the spine grows away from the cord, so that at birth the end of the cord comes to about the level of the third lumbar.

But just why union of the edges of the neural groove should fail in part or entirely as so happens in spina bifida is no better known now than it was in the time of Saint-Hilaire. Cases are recorded wherein the vertebral bodies are cleft, half-developed, and absent entirely and these deformities have not always been accompanied by a defect dorsal to the central canal of the cord. To a dorsal cleft the name spina bifida will refer in this article, although the French name, spinal fissure, might perhaps be more appropriate.

The defect, as one would suppose, is more common in the regions where normally union of the neural groove is latest, namely, toward the ends of the spine. Moore studied all those in the Surgeon General's index up to 1905 and found 86 per cent. lumbar or lower, 9½ per cent. cervical and the remainder (4½ per cent.) dorsal.

When the cleft reaches from the skin to the central canal of the cord, the more or less "opened-out" cord usually appears as a reddish strip from

one to two centimetres wide and of variable length lying in the centre of the back. This strip is not covered by the normal surface epithelium. It has a moist granular appearance and flakes of fibrin or inspissated mucoid, or even crust-like plaques may be seen on it. Microscopic examination reveals columnar or cylindric epithelium, unless this has been rubbed off or ulcerated. Clear fluid wells slowly up from its centre only if the cord is cleft to the canal. Around the margin of this red strip, the surface is covered usually by a thin, pearl-gray, scar-like pellicle. This usually thickens as it passes outward—may become quite hard and scar-like—and joins the normal skin abruptly. There may be no tumor at all, the surface may even be depressed, groove-like, but most often this whole abnormally covered area, with the adjacent healthy skin, protrudes more or less, depending on the tension of the subjacent cerebrospinal fluid in the arachnoid space. When a tumor exists in such a case, it is never pedunculated but always has a wide base.

The above type of spina bifida without tumor has been called myelocoele, and with tumor, myelocystocoele. It would simplify matters to refer to them as plane and cystic myelocoele. In all these cases it is highly probable there will be accompanying paralyses. Such paralyses are due to lack of development of the cord centres and not to the cord's position, and they are, therefore, not likely to be benefited by operation. Or the failure of union of the sulcus may reach from the surface of the body to the cord only, involving the arachnoid or pia or both. In such, the cord is found in the sac where it usually adheres to the roof and sometimes terminates in it. (Cases I, II, and XII.) This type is called the myelomeningocoele. The surface of such a tumor may or may not be entirely covered with epithelium—a granulating area or several—may exist along its summit, and the same thin, pearl-gray coat seen in the myelocoele is sometimes found. It is not usual, but it does happen, that the normal skin may cover a tumor of this type, *i.e.*, a cystic tumor containing the cord. The cord is not always attached to the roof, but may lie free in the sac.

A structure much resembling cord in gross appearance, except that it has no nerve roots attached to it, is sometimes seen in this form of tumor. One end of it is attached to the cord, the other to the roof of the sac, which it causes to dimple in. It has been found in the dorsal region (Case VII), and in the lumbosacral region (Case X). When found in the lumbosacral variety, it may contain a canal continuous with that of the spinal cord and open out on the roof so as to look like a myelocoele. These processes were first noticed by Förster. On section they are found to contain nervous tissue toward the inner end, and skin elements toward the outer—or they may retain the nervous elements throughout. Those found along the continuity of the cord are probably remains of the fused but unabsorbed walls of the neural groove at that level. Those occurring as a continuation of the cord represent the lower coccygeal segments of the embryonic cord which should have remained only as the filum terminale. If such a process is canalized throughout, cerebrospinal fluid is discharged at the summit of the tumor. This and

the surface appearance may give rise to the diagnosis of myelocoele with refusal of operation—a serious mistake.

When the cord is attached to the roof in any way, traction is made on the cord as the column lengthens. This may produce paralyses of various kinds although cord and nerves are quite normally developed.

Syringomyelocoele, the form wherein the tumor is due to the protrusion of a portion of the cord distended by the accumulation of fluid within the spinal canal at that level, I have not yet seen.

The simple protrusion of meninges—meningocele—in which the defect is one of development of the arches of the vertebræ, offers no difficulty. They are usually entirely covered with normal skin and pedunculated. Usually not more than two arches are involved. I do not believe it is possible to be certain it is merely a meningocele until the sac is opened.

Von Recklinghausen insisted that in every spina bifida there existed a dural defect. This has been so in ours, but there has always been more than enough dura to close the defect.

When the abnormality presents a trough-like depression covered with what looks like mucosa or granulation tissue, and from the centre of which clear fluid wells up, one cannot be certain that this is a myelocoele, and the reddish area, the opened-out cord. (See Case XI.) This is an important fact and not generally known; hence, I repeat it. When, however, such a tumor appears above the lower lumbar region, I believe the diagnosis of myelocoele is warranted.

A dimpling of the surface of the tumor is strong evidence of the presence of the cord within the sac, but it is not a certain sign thereof. Nor is the observance by transillumination of cord-like structure within the sac a certain diagnostic sign. One must look inside to be certain.

But it is not the presence alone of the cord which is important, rather is it the extent and cause of the accompanying paralysis which concern us most. The paralysis may involve only one muscle group or a part of a group—it is often total paraplegia. It is a flaccid paralysis. The uninvolved muscles draw the joints into abnormal positions. Thus, club-foot, dislocated hip, *etc.*, may be produced. One should test for sensory paralyses as well; they usually co-exist.

As has been said, various paralyses may exist even though the cord be normally developed and what looks like a myelocoele may be unaccompanied by paralysis. (Case XI.) The pressure or traction of abnormal bands or strands of arachnoid may be sufficient to prevent normal cord function. That this is so in spina bifida occulta, no one any longer denies.

How then is one to determine the cause of an existing paralysis? In order to make a correct prognosis the cause of the paralysis must be known.

It seems to me that (excepting the myelocoeles above the lower lumbar region) there is no known certain way of determining the cause of a paralysis in the presence of a closed sac—the surgeon must first see the interior of such a sac and examine the cord, nerves and membranes.



A properly developed cord may not function because of traction, *etc.* Such a cord carefully released and restored to its bed may possibly function normally. I have found no well-authenticated case, but improvement has been noted. But an "opened-out" cord in the roof of the sac is another matter. Such a cord is not normally developed and the operation for its replacement in the canal (it can be successfully accomplished, see Cases IV, V and IX) must necessarily traumatize it and still more curtail its function. Therefore, to expect to benefit an existing paralysis by operation in the case of myelocoele, plane or cystic, is a vain hope.

A paralysis of both legs or of one may be a great handicap. None the less, one may live a very worthwhile, and even a happy life, whether viewed from his own standpoint or that of his associates.

A paralysis of bowel and bladder, however, that causes incontinence of faeces and urine, is a far different condition. This practically condemns the patient to a life of ostracism which begins when he reaches school age and lasts the remainder of his life. Paralysis of both sphincters—anal and vesical—may occur with only very slight paralysis elsewhere. (Case I.) It is conceivable that they alone may be paralyzed.

The absence of the anal reflex is a constant clinical sign of paralysis of the anal sphincter, but the reflex may be absent because of sensory paralysis alone. However, a paralyzed sphincter gapes and has a loose feel to the examining finger.

No one, so far as I can learn, has yet reported a single case wherein a congenital paralysis of bowel or bladder was cured by operation for spina bifida. The history of Case II would seem to contradict this, but it will be seen that although the statement is made that "the bowel moves constantly," it is also stated that "anal reflex is present." This child still has a weak sphincter, but has not incontinence—and I think he never had.

Coffey has done a great deal toward the perfection of a technic for the successful transplantation of the ureters into the bowel. Such an operation in the presence of a paralyzed sphincter ani would likely not improve the patient's condition.

For a paralyzed anal sphincter alone, a sigmoidostomy properly performed ameliorates the condition of the patient. Unfortunately, in spina bifida the paralysis of sphincter ani is not likely to occur without accompanying vesical paralysis. In such a case, a sigmoidostomy following or followed by caecal or sigmoid implantation of ureters would probably not improve matters.

For a paralyzed vesical sphincter alone, however, Coffey's operation seems to be the best so far developed.

In spina bifida, to operate or not to operate is the question one must decide. Will it be better under all circumstances to operate than to leave the case to nature?

What will happen to those left unoperated upon? The patient with spina bifida of the myelocoele or myelocystocoele variety, if left alone, will most likely soon die. If there is leakage of cerebrospinal fluid, meningitis

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will soon ensue. When the covering of the sac of a meningocele is thin, it very likely will become ruptured as soon as the child begins to creep about, if not before.

The patient having meningocele covered with normal skin may grow up to adult life. One was exhibited some years ago before the St. Louis Medical Society by Doctor Jonas. Such a thing is not common.

In 1913, Froelich came to the conclusion that the operative mortality was so high (64 per cent. in his study) it was better to counsel non-interference, as he found it only 29 per cent. in the non-operated. Cutler (1924) reports sixty-five operations on selected cases at the Children's Hospital, Boston, and found the mortality to be 47.65 per cent. Moore collected and studied all the cases on file in the Surgeon General's index from 1813 to 1905. The average mortality of the operated cases—385—was 27 per cent. He found the mortality 35 per cent. for those in the first months, but in those of five years or more the mortality was 4.7 per cent. Harrar (1916) reported thirty-four cases with sixteen deaths (47 per cent.). Romanis and Mitchiner (1929) advise that "cases which seem on the point of rupturing should be operated upon at once—others are best left alone." Homans gives 50 per cent. as the mortality. My own experience is that if the case comes to the *proper kind* of operation *early enough*, the question of operative mortality can be ignored entirely.

The presence of hydrocephalus is said to contra-indicate operation. There were three which showed signs of the condition. Since operation, one of these has died of it (Case IX), one is alert mentally, but hydrocephalic (Case V) and one we could not trace (Case XII).

It is my opinion that any case not having vesical and rectal paralysis should be operated upon. I also believe that the best time to operate is as soon as one can get the baby. Babies under three days—or even a week old—do not shock so much as when they are older. Furthermore, the head-down position is still natural to most of them, and it is to be maintained for some length of time.

There are many different types of operation. I believe that there are certain details which make for low mortality.

The position of the patient during operation and afterward I regard as of the utmost importance. Abbe, in 1893, was the first to stress this point. Von Bergmann, in 1899, emphasized it, saying that he always operated with the child's head well down lest sudden change in the intracranial tension interfere with brain metabolism. He also kept the child on its side with the head low afterward—"on no account must the position be changed." W. Babcock has also urged its importance.

I feel sure the loss of even a little spinal fluid at operation or afterward might easily cause death in certain cases. Not only have all those reported here been operated upon in this position (Fig. 1) but all have been kept in this position for at least six days—for at least two days after cerebrospinal fluid has stopped draining.

Prevention of contamination both during and after operation, I feel, is helped somewhat by the rubber dam of Eastman. He sewed it to the skin. I have applied it with rubber cement and it is kept on for days. Von Bergmann covered all with collodion dressing.

The length or duration of the operation is important. Nothing should be done that is not necessary. The first step should be an incision into the sac. This is for the purpose of making the diagnosis exact and complete. Such incision should be longitudinal, near the anterior end of the tumor, and 1.5 to 2 centimetres from the mid-line. This will not injure cord nor nerve roots. After opening the sac, one can quickly determine the site of cord or nerves if either be present. In further progress of the operation,

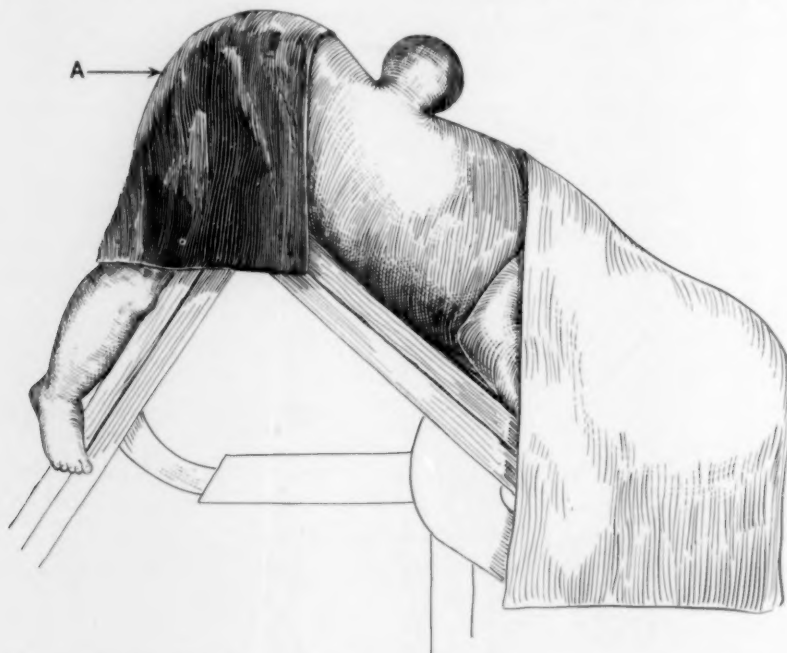


FIG. 1.—Position during operation and for some days afterwards. A—Rubber sheet, fastened to the skin with rubber cement.

he now knows at least where not to cut. If nerves pierce the sac wall they course through the tissue between skin and sac on their way to their respective foramina of escape, and may be cut if one is not aware of this. I do not know whether it would make any difference if they were cut.

An elliptical incision (Harmer), its long axis transverse, is the kind I prefer. It is just of such a width as will conserve as much as possible of the normal skin to facilitate closure. It has the advantages that, when closed, the deep and superficial sutures are not in the same plane, and leakage of cerebrospinal fluid is not so likely, and also the edges are better supplied with blood than are those of a vertical incision. Beginning at the angles, the skin and fat are carefully reflected until the pedicle or base of the sac is reached (Fig. 3), taking especial care when exposing the caudal aspect of

this, that nerves leaving the sac are not severed. The redundant part of the sac is cut away, leaving just enough so that closure may be without tension. The cord may have its tip (Cases I and II) or a portion of its dorsal aspect, or the filum terminale (Case XI) adherent to the roof. If such is the case, and the cord be normal, a careful separation of the overlying covering—it may be but a thin layer of squamous epithelium—must be made. Obviously, it will not do to return epiderm to the canal with the cord. The embryonal remnants (?) found in Cases VII and X were at first sight thought to be cord and were attached to both cord and roof of sac.

If the cord be "open" and forming part of the wall of the sac, it is possible of successful restoration to its bed, although Keiller and others deny this. (Cases IV, V, and IX.) The "raw" surface must be sterilized and, if epithelium covers it, this must be removed. One must bear in mind, however, that most likely this cannot be done without further injuring what is practically always a defectively developed cord. I have sterilized such a spot with the actual cautery (Cases IV and V) but it causes too much destruction. Later I sterilized the surface with 1 per cent. mercurochrome twice daily for several days previously (Case IX), then shaved off a thin layer under a stream of saline, using a very sharp knife. The surface has never bled seriously. When cord and nerves have been returned to the canal and the redundant sac cut away, the sac is closed transversely with a continuous plain No. 00 catgut suture—"serosa to serosa." This suture line is less likely to adhere to the cord if it is transverse.

Some have advised reconstruction of the bony canal. Osteoplastic flaps have been raised from the ilium and from the spine itself—Dollinger, von Bayer, Bobroff, Hildebrand, *et al.* Such procedure lengthens the operation, increases the trauma and produces much shock, and when completed is unnecessary. The cases do quite well with a simple turning of a flap of the lumbar fascia, and some do as well without any flap at all. (Case I.) I use the double flap of von Bayer cut as shown in Fig. 4, and turned backward and inward, one falling over the other—one suture is enough to hold them.

The closure of the wound is then made transversely. When the defect is very large, an incision is made across the back parallel with the upper edge of the defect, of equal length with it and at least three inches from it. (Fig. 5.) The skin and underlying fat between the defect and this incision are now carefully raised up from the deep fascia. This gives a flap attached at both ends—flap of Celsus (?)—which slides easily down and is sutured to the lower edge of the defect. It is sometimes necessary to make the parallel incision longer at each end, so that the flap can be brought down without tension. One can gain something by undercutting the lower edge of the defect, but I try to manage so as to have the superficial suture line well below that of the closed sac. The upper wound is now a defect, which is allowed to heal by granulation, dusting it with bismuth subiodide powder and laying a piece of rubber dam or oiled silk on it.

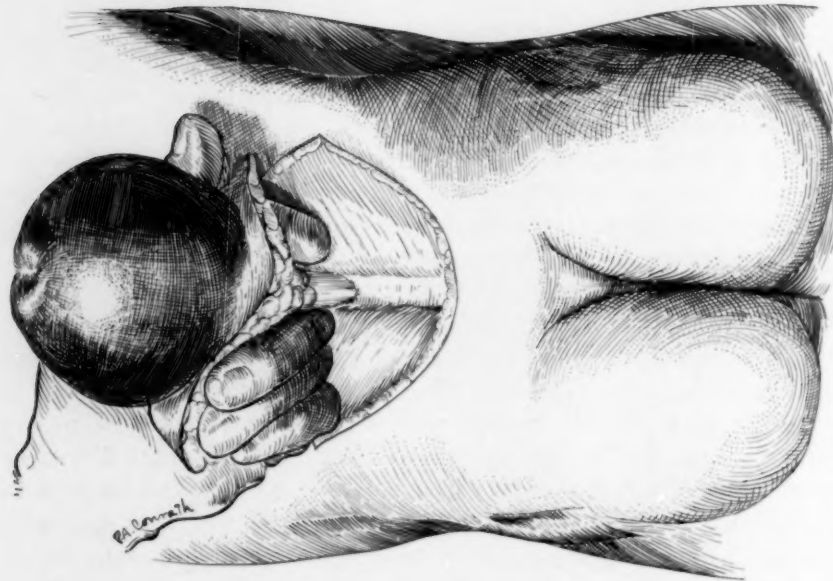


FIG. 3.—The skin and fat are lifted up from the edges toward the centre, taking care to avoid cutting nerves that lie on the outside of the pedicle. They are sometimes found below and laterally.

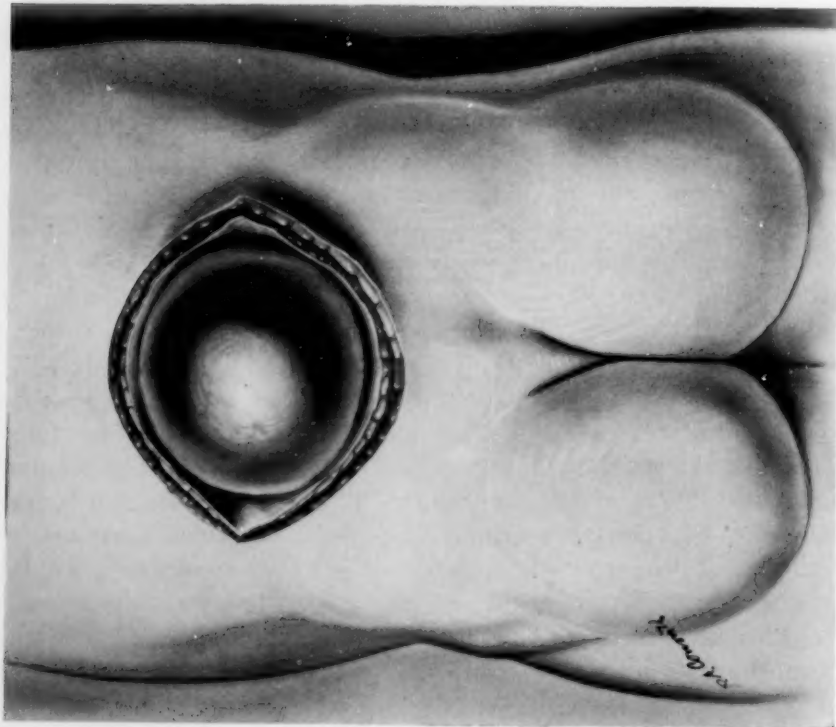


FIG. 4.—The tumor is excised transversely, saving as much of the normal skin as possible. The artist has made the long axis relatively too short.



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The patient is kept constantly in the head-down position for the next six or seven days. The wound is dressed daily and the sutures carefully inspected and removed at the first sign of irritation. If closed without tension on the suture line, healing will be firm within a week. In no case does cerebrospinal fluid escape through the suture line, but it is not unusual for it to escape under the flap up toward the defect—not much, after the first week.

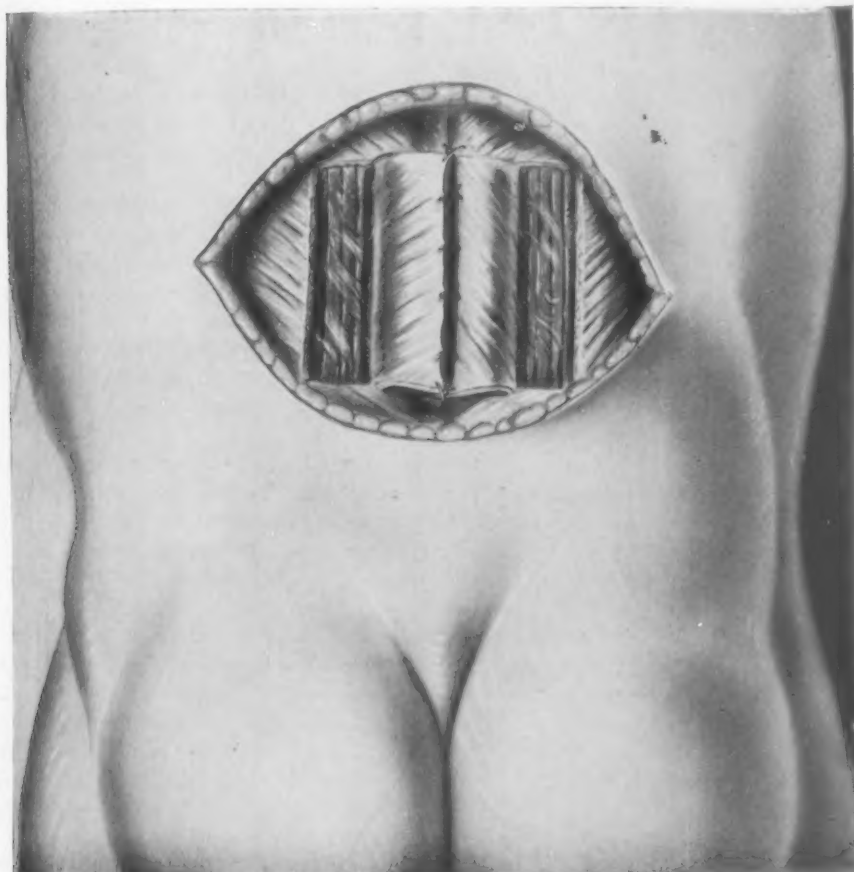


FIG. 4.—Two flaps of lumbar fascia, of appropriate length and width, the base of each toward the mid-line and close to the defect, are turned over backwards, the one to overlap the other. One suture is enough to hold them together.

In none of the cases have I made any attempt to construct an osteoplastic flap and in none is there a recurrence of the condition.

CASE I.—St. John's Hospital, Gen. No. 406, admitted November 8, 1920. Referred by Dr. K. C. Spain. An apparently healthy boy two days old. The parents are healthy Americans of English stock. There are four other children in the family, all normal and healthy. No history of any deformities in the family. No history of lues. Wassermann, negative.

There is a tumor in the mid-line of the back in the lumbar region, just above the sacrum. It is somewhat hemispherical in shape and about 5 by 4 by 2 centimetres. It is

"dimpled" at the summit, and from the edge of the dimple through a small opening, clear fluid is exuding drop by drop. The tumor, for one-third the distance from this dimple to the base, is covered with a thin, pinkish-gray, dry membrane which is continuous with the normal skin, which covers the lower two-thirds of the tumor.

Doctor Spain informed me that at delivery, the tumor was tense and glistening and that there then was no leakage, and that twelve hours later the sac was leaking and wrinkled instead of tense. When first seen by me, the day before operation, the tumor was only moderately distended, its surface was soiled with recent feces, and the clear fluid referred to was issuing from the opening at the edge of the dimple at the rate of about twenty drops per minute. The dimpled or puckered part had an ulcerated or raw appearance. There is an increased redness in the pinkish pellicle at the edge of the opening and the exudate on the raw surface looks like pus. When the baby cries the tumor increases in size, and the fluid flows faster. Feces and urine escape from time to time. The anus seems open—it is certainly not drawn in and puckered in the normal way. The limbs are kept in strong flexion, and the baby seems to move them voluntarily.

Operation was performed when the child was approximately sixty-six hours old. The baby was held in face-down, head-down position, its feet and legs drawn downward over the end of the table, so that the axis of the body was at about forty-five or fifty degrees with the horizon, and the axis of the thighs at right angles (or less) with that of the body. Ether was given on the open mask. The field was sterilized with half-strength tincture of iodine, removed with 95 per cent. alcohol. The Percy cautery at a black heat was lightly applied to the edge of the opening in the pellicle, and to the raw surface in the dimple, and again tincture of iodine was applied over the burned area, and round about over the tumor.

The tumor was removed by a transverse excision, elliptical, cutting through the skin covering the tumor half-way between summit and base. Sac and skin attached to it were removed. Some nerves were cut, as they lay imbedded in the sac wall. The cord was attached near its end to the dimple in the summit of the sac, and on cutting it free, it bled rather freely from a single vessel. This was ligated, and the opening in the dura (?) closed transversely, serosa to serosa, with continuous plain No. 00 catgut.

The defect was about two inches wide at its middle. A transverse incision was made through skin and subcutaneous fat about three inches above the defect. The intervening skin and fat flap was now lifted up—as in Fig. 5—and the flap was slid downward and sutured to the lower edge of defect with interrupted silkworm gut and continuous No. 00 plain catgut (epidermal) sutures. The defect left above was dusted with bismuth subiodide powder and covered with a rubber strip. A dry dressing was applied over all. There was lost only what cerebrospinal fluid the sac contained, and the baby was in splendid condition.

The orders were to feed as usual and keep baby constantly in the position maintained during operation; to give paregoric for crying or restlessness.

The recovery was uneventful. November 20 the last sutures and dressings were removed, and November 21 the child was removed from the hospital.

The discharge note says the bowel does not move as often as before operation, and there is no bulging—there was no fascia flap used in this case. The leg movements were as before operation.

The further history is that at about the age of one year the feet were noticed to be in talipes varus position, and orthopaedic appliances have been used more or less constantly ever since. At present, the child, now eight years old, is well grown for his age, and seems far above average intelligence. There is no sign of hydrocephalus; vision, hearing, speech and intellectual processes are excellent, nor is there any bulging at the site of the operation. The feet are in equino varus, the left in first and the right in

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about second degree. However, he gets around lively enough, and without fatigue or pain, except when wearing the appliances; consequently, he wears these only rarely.

There is absolutely no control of either bowel or bladder; he wears oil cloth or rubber "bathing trunks" which, clinging tightly to the skin of the thigh, prevent the escape of urine and feces. He cannot go to school, as "he needs attention too often," his father says.

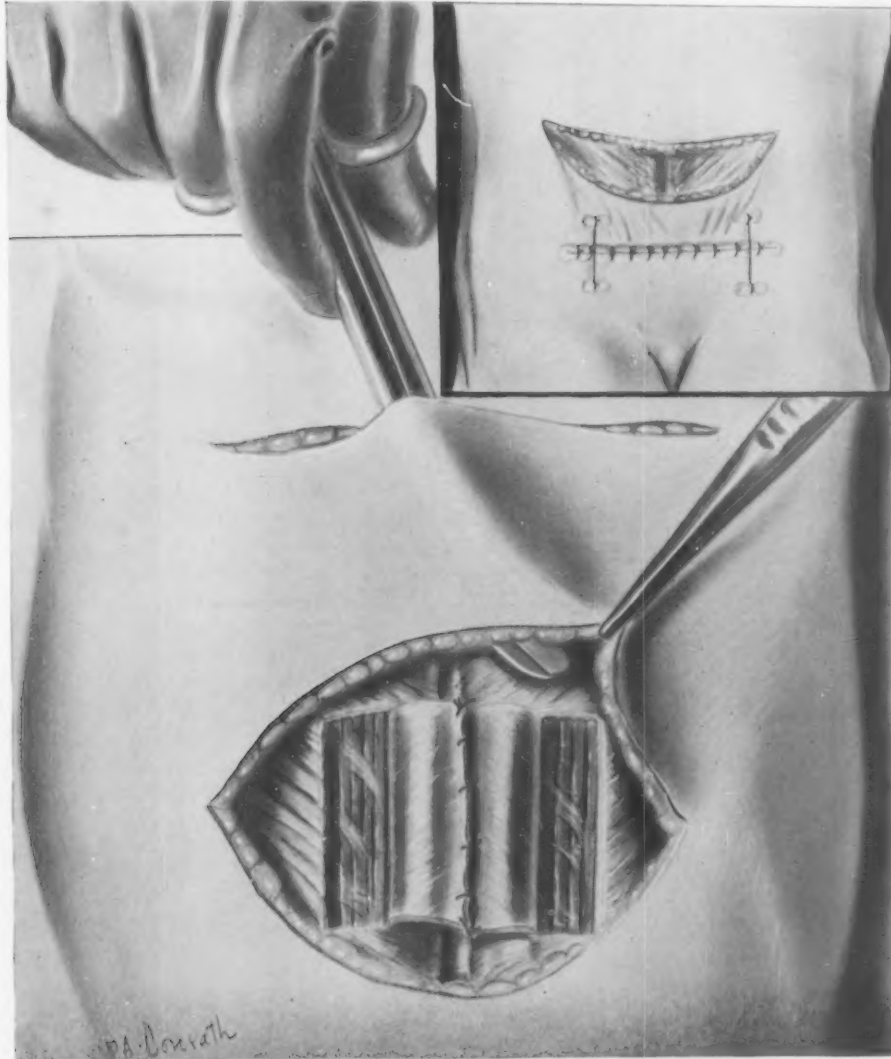


FIG. 5.—The defect is closed by a flap. An incision is made through the skin and fat at least three inches above the defect. The intervening flap is raised up and the upper incision is lengthened as much as is necessary to allow the wound to be closed without tension. The defect is now above. It is allowed to heal by granulation, is dusted with bismuth subiodide powder and covered with a bit of rubber. Some cerebrospinal fluid is likely to be discharged during the first few days. Insert illustrates the final closure.

When I visualize this child grown to manhood with this condition unchanged, I wish I had never operated on him.

CASE II.—St. John's Hospital, Gen. No. 2764, admitted June 13, 1921. A healthy boy baby, five days old, American, first baby, no history of deformities in either side of

family. There is a tumor in the mid-line of the back, in lumbosacral region, almost hemispherical, about half the size of a large lemon, elevated three-fourths to one inch above level of surrounding surface. It is covered with normal skin for only about one-fourth inch above its base, the covering here changes from skin to a thin, pinkish, semi-transparent pellicle. At the summit is a spot from which the epithelium is missing, and which is covered with a scab or crust. The tumor has a translucency somewhat like that of apple jelly, and in the depths in the upper left quadrant and in the mid-line, are pinkish-white opaque masses. On pressing the tumor, the pellicle dimples but fontanelle does not bulge, nor does baby seem to be distressed. However, when the fontanelle is pressed upon, bulging can be felt in the tumor. Anal reflex is present, bowel moves constantly. There is no paralysis in lowers. No hydrocephalus.

*Impression.*—*Meningomyelocele.* With the idea of avoiding rupture of the thin-walled sac with ensuing meningitis, operation was undertaken at once.

Under ether on the open mask, the surface was sterilized; the raw surface at the summit was touched with the cautery and slightly charred. A transverse elliptical excision through normal skin at base of tumor, cutting the skin and fat only. Reflected skin and fat upward from all around, till sac was exposed. Opening sac, we found the cord and a mass of nerve roots rather "bunched up" and attached to the roof under the charred area. The sac was cut away, removing a thin layer of cord tissue along with it. As much as possible of the neck of the sac was left (all that was covered by normal skin). The roots and end of cord were pushed forward into the open canal. The spot on end of cord, where it had been cut free from the roof (in the bottom of the dimple referred to) bled freely. A small vessel was ligated, and the cord and nerve roots dropped back in the open canal. Two flaps of lumbar fascia, one on each side the opening in the canal, their bases toward the mid-line, were lifted up and turned over backward. The sac was so thin and the opening so wide that no attempt was made to close it separately, but it was included in each flap. The flaps were turned over backward and easily overlapped by about 1.5 centimetre. The external wound was closed transversely, making a transverse incision through skin and fat, three inches above, and undercutting to relieve tension and allow sliding.

Examination of the sac removed showed that where the cord had been cut from it, there was a whitish, hard area (on the inner surface of sac). This was less than one centimetre in diameter, and appeared to be made up of two symmetrical halves. Microscopic examination by Dr. R. L. Thompson: "The material at summit of sac is nervous tissue and appears to be a part of the cord, the central canal of which is widely dilated. Fusion of the dura with this can be made out. No nerves appear in the section."

The child made an uneventful recovery. In 1923, the following note was made: "The baby's body is very large, the head is large and the brow projects. There is lateral nystagmus, both eyes. Pupils are equal and react to light. The baby seems of normal intelligence. It has not yet learned to walk alone. There is spasticity of both legs, increased on attempts to stand. The right foot is smaller. No club-feet. There is no bulging at the site of scar. There is a well-marked 'post-anal dimple' about one and one-half inches from the anus. There seems to be incontinence of urine—the diaper is constantly wet. The skin about buttocks and perineum is red and it looks red and raw, with flat warts growing abundantly everywhere. It does not bleed when rubbed or washed, nor does it seem tender. This is said to have first begun during an attack of diarrhoea when the child was one year old." He was sent to the orthopaedist.

The child was examined by me in July, 1930. At the site of the tumor there is no bulging whatever. There is a distinct pulse feelable on palpation. Halfway between the scar and the anus is a dimple. On the under aspect of either buttocks, where patient sits, the skin has a peculiar scar-like appearance—no condylomata. There is a thickening of the skin of the scrotum, and it has a peculiar, hypertrophied appearance. The

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child can lift its legs and move them. There is a certain amount of spasticity in the legs. They are not well developed. He has both flexion and extension of knees and hips. There is valgus of both feet but not marked. He has sensation in legs—can feel heat, cold and pin pricks. He is healthy, happy and intelligent. Walking with crutches. Has spastic lowers, certain tendency to "scissor-legs." Has acquired a certain amount of control over bladder—urinates at regular intervals. Never soils clothing by rectal discharges unless he has diarrhoea.

*Comment.*—This was a meningomyelocele. No defect of cord, and before operation anal reflex was present, although the bowel seemed to be moving constantly. Left to himself after operation, this would have been a wheel-chair case, but the orthopaedist—Dr. A. E. Horwitz—has done a great deal.

CASE III.—St. John's Hospital, Gen. No. 7631, admitted August 2, 1922. An apparently healthy girl baby, four days old, weight seven pounds, normal delivery. Three other children in family all living and well. Has no other deformity, nor is there any family history of such. Baby nurses well. Seems to move limbs normally and the bowel and bladder seem normal.

There is a tumor in the mid-line of the back, just below the occiput against which it touches. It is spherical and about three inches in diameter, attached by a pedicle one and one-half to two inches in diameter to the middle of the back of the neck. The pedicle and the proximal half of the tumor are covered with normal skin. The remainder of the tumor is covered with a thin, grayish-pink membrane, in which ramify many large and small veins. In the left inferior quadrant this membrane bulges as a sort of diverticulum. The mass transmits light throughout, but is opaque. It does not appreciably tighten when the baby cries, but pressure on it seems to raise the tension at the anterior fontanelle.

*Operation.*—August 2, 1922. The baby was given ether on the open mask and anesthetized in the usual head-down position. Iodine-alcohol sterilization. Transverse, elliptical incision, crossing the sac through normal skin just below its junction with the thin pellicle mentioned. Withdrew twenty cubic centimetres fluid (cerebrospinal fluid) from sac to relieve tension. Incision carefully deepened and flaps lifted up from ends of ellipse toward mid-line until sac and pedicle were encountered. When the sac was held up tight, the pedicle measured about three-fourths of an inch across. The muscles were dissected well back from pedicle until bone was encountered. Two clamps were applied transversely, and the pedicle was cut between them. Very little cerebrospinal fluid was lost besides what was in the sac.

The neck of the sac was closed (serosa to serosa) by transverse, continuous suture—No. 1 plain catgut. A flap two inches by one and one-half inches was made on either side, their bases close to the pedicle. They were thought to be of trapezius aponeurosis. These were turned over backwards covering the pedicle, and the edge of one overlapping the edge of the other. They were sewn to each other with mattress-silk sutures, and, after making good hæmostasis, the skin was closed with slight undercutting and sliding. No drain.

The convalescence was uneventful. There was nothing to indicate any trauma to cord or spinal nerves.

On gross examination the interior of the sac showed, here and there in its wall, small recesses, and one of these, larger than the other (referred to above) was in the left inferior quadrant. There were no nerve roots visible, yet the microscopic examination of a section from the sac near its base shows "nervous tissue present"!

Present condition, as reported by Doctor Clithero, is that the child has developed normally, is very intelligent and has no paralysis and no sign of hydrocephalus.



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CASE IV.—St. John's Hospital, Gen. No. 11222, admitted June 7, 1923. A girl baby three weeks old. Three other children in family, all normal. No history of deformities in family.

There is a tumor in the mid-line of the back, about the lumbosacral region. The tumor is hemispherical, about two inches in diameter. The normal skin mounts on the sides of the tumor for about one inch, and then gives way to a thin, bluish-white, shiny membrane, which is continued to the summit. There is a raw, granulating area on the summit, a little more to the right, about  $1\frac{1}{2}$  centimetres by 1 centimetre, and clear, watery fluid is coming out of the tumor at the upper edge of this area. The raw area is covered with a grayish mucous matter. The tumor bulges when the baby cries. *Impression.*—Cystic myelocoele.

The anus is gaping wide open, the mucosa is everted about the edge, and seems gathered in little lumps. There is no anal reflex and faeces are expelled from time to time. The legs and feet look normal, and baby moves them apparently normally.

The parents were informed that, left to itself, the child would most likely soon die of meningitis; that if the child lived it would probably lack control over the bowel whether operated upon or not. They decided to have the operation performed.

*Operation.*—June 7, 1923. The skin was sterilized with half-strength tincture of iodine which was washed off with 95 per cent. alcohol. The operation was done in the usual position, body at an angle of forty-five degrees, head down—lowers hanging down, buttocks up—ether given on the open mask. The raw granular surface was cauterized and about fifteen cubic centimetres of slightly turbid fluid were aspirated. A transverse elliptical excision was made through the normal skin, saving as much of this as possible above and below. Dissection was made from the outer ends of the ellipse toward the mid-line, lifting skin and subcutaneous fat until the pedicle of the sac was encountered. The sac was opened to the right of the mid-line, cephalad to the raw area. The cord and cauda seemed to attach themselves to the roof under the raw area. The sac was opened in the mid-line below the raw area and the most of the nerves were seen to end in the summit of the sac. The pedicle of the sac was cut through transversely, leaving enough to close. The nerves and cord (?) were cut from their termination in the sac and returned to the open canal.

The opening in the dura was closed transversely, and a flap turned up from fascia on either side, their bases toward each other, one on each side of the opening. The opening in the column was one inch vertically and three-fourths inches transversely, each flap about two inches long by one and one-fourth inches wide. They were turned over until one lay over the other, closing the canal. They were sewed together with plain No. 0 catgut. A transverse incision, three and one-half to four inches long, was made through the skin and subcutaneous fat about three inches above the upper margin of the defect. The skin and fat between this incision and the defect were undercut, and the Celsus flap thus made was slid downward and sutured to the lower margin of the defect with interrupted silkworm gut, epidermal approximation with continuous fine "dermal" suture. The defect left by sliding the flap was sprinkled with bismuth subiodide powder and a dry dressing applied.

The baby was kept in the head-down, face-down position with lower limbs hanging down over a pillow for the next ten days. The spinal fluid Wassermann was negative. June 10, 1923.—The baby seemed drowsy and there was a purulent discharge from wound. Some of the sutures were removed. June 12, 1923.—The baby was better. Culture taken June 10, 1923 showed *Bacillus coli*. The further course was uneventful and the baby left the hospital June 27, 1923.

The present condition of the child as reported by the physician in charge, Dr. J. H. Cochran, of Gideon, Missouri, is: "The child is living and well. There is no control whatever over bowel or bladder. A diaper is worn constantly. The child is above the average intelligence. There is a moderate talipes calcaneus, but she walks pretty well.

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One eye is crossed. There have been no ulcers on buttocks, legs or feet, and sensation seems normal."

*Comment.*—In this case the incontinence was positively diagnosed before the operation. The anus was gaping and there was no anal reflex. The surprising thing is that there was no paralysis of limbs produced by the operation. The raw area was sterilized with the cautery.

CASE V.—St. John's Hospital, Gen. No. 11541, admitted July 4, 1923. A girl baby, one day old; first baby; no history of deformity of any kind.

There is a cyst-like tumor mass in the mid-line in the lumbar region. It is about one and one-half inches in transverse diameter and a little longer in the vertical. It is about two centimetres in height. The surface at its base is skin of purplish color which extends to skin over sacrum, and here there is a growth of black hair and a dimple in the mid-line lower down. The skin ascends around the tumor almost half way to its summit, and here is replaced by what looks like thin scar tissue which is continued to the flattened summit where it ceases around the margin of a moist, raw, weeping area, one and one-half by two centimetres, of yellowish-brown, granular appearance. The tumor contains fluid—but not under tension as the covering of the tumor wrinkles somewhat—no fluid escaping. There is a dimple in the mid-line half way between the lower margin of the tumor and the anus. *Impression.*—Cystic myelocoele.

The anus is everted; there is no anal reflex; the urine dribbles. It moves the lower limbs, but these are not drawn up on the abdomen.

*Operation.*—The child was placed in the usual position, the field sterilized with half-strength tincture of iodine, which was removed with alcohol after four minutes. The buttocks and anus were then excluded from the field with a rubber-dam sheet cemented to the skin above the buttocks—Eastman. A cautery was lightly applied to the granular surface. The sac was opened just lateral to the granular area; a small amount of cerebrospinal fluid escaped. The sac was clipped away from around the margin of the granular area. This was the dorsal aspect of the lower end of the cord. Nerves could be seen streaming from the sides of this and passing into the ventro-lateral and inferior aspects of the anterior walls of the cavity; it seemed as though the spinal canal had become superficial to the spine. The sac was then excised in transverse ellipse and while dissecting toward its base or "pedicle" from below, nerves were encountered emerging from it and apparently passing in the subcutaneous tissue over the back of the sacrum. Some, while still in the wall of the sac, were accidentally cut. Enough of the sac (dura?) was left to cover the cord and nerves, and two rather generous flaps were lifted from over the erectores spinæ so that no pressure should be made by them when united over the cord. The usual flap (of Celsus?) was made above and slid down to cover the site of operation.

The child was kept in the head-down position for the next week. The sutured wound healed by first intention; the convalescence was uneventful. The condition of bladder and bowels remained unchanged, but there was no movement whatever of the legs. What I considered peculiar was the fact that the central canal of the spine seemed to have become superficial or, rather, ended by becoming superficial, in the mid-lumbar region. Whether the paralysis of the limbs was completed by cauterizing the raw area or by accidentally cutting roots (some were cut), I do not know. It was not likely due to the pressure of the flaps, as these were loosely applied and paralysis appeared immediately.

At present, I am informed by the family doctor, the child is alive and well, alert mentally, but has marked hydrocephalus and is totally paralyzed in both lower limbs, rectum and bladder.

*Comment.*—It will be noticed that in many of the histories the statement is made that the sac wrinkles or does not bulge when the baby cries, as though there were not direct continuity with the general subarachnoid space, the defective area walled in, as it were. This is interesting when we remember that as late as 1885, a commission appointed in England agreed that the best results were to be expected from treatment by injection of iodine, *etc.*

CASE VI.—St. John's Hospital, Gen. No. 12315, admitted September 7, 1923. Girl baby, seven days old. Father and mother had always been healthy. No history of any kind of deformity in family of either. One other child five and one-half years old, healthy. The mother had been "badly shaken up" in an auto accident during the sixth month of this pregnancy. The child does not move its legs. They hang flaccid when child is held up. There is a tumor, oval in shape, in the mid-line of the back. Its upper edge is just about the last ribs. Its long axis is vertical, about two inches long, and it is about one and one-half inches wide in its widest part. It is dark red or purple in color, is raised about one inch above the level of the back. It is covered with a very thin pellicle which is translucent and through which fluid can be seen. At its summit is a depression, also oval, with long axis vertical, nearly two centimetres long and half as wide. The floor of this dimple or depression seems pulled in, is yellowish-red and granular, and is not covered by the pellicle covering the tumor elsewhere. Nor is this floor translucent as the pellicle is. In the mid-line in the bottom of the depressed granular area, and rather nearer its upper end, is a tiny orifice from which a clear fluid wells slowly up. The upper edge of the depressed area comes to within one centimetre of the upper edge of the tumor and between these points in the mid-line, a structure thought to be the cord is visible through the thin covering in the translucent depths of the cyst-like tumor. There is no anal reflex. The anus has a loose, open appearance and urine dribbles from the vulva from time to time.

Confident that the condition was a cystic myelocoele and owing to the fact that there was paralysis of limbs and sphincters, operation was advised against, but was agreed to at the urgent request of the parents who felt they were morally obliged to make an effort to save the child. In sterilizing the raw area by the cautery in a case which seemed somewhat similar in appearance to this (Case V), there is no doubt the paralysis of the legs was made worse. I therefore decided to use tincture of iodine—3½ per cent.—and after three minutes to wash this off with alcohol, and then to slice away a very thin layer of the raw surface from above downward under a stream of saline.

*Operation.*—September 7, 1923. The baby was placed in the head-down position and anæsthetized with ether given on the open mask. The sterilization was carried out as planned. The sac was opened in the mid-line above the depression and the cord was seen to emerge, normal in appearance, from the canal above and to terminate by attaching itself to the roof of the sac at the bottom of the depression, and, flattening itself out strap-like, it formed the roof of the sac in the bottom of the depressed area. Opening the sac in the mid-line below the depressed area, no cord could be seen but many strands identified as nerves and filum streamed from the under surface of the depressed area. None of the nerves followed or adhered to the lateral walls of the cyst, but all were traced forward toward the longitudinal hollow which we took to be the open spinal canal.

The cyst wall was cut away from the edge of the granular area. It was very thin but not so weak as one would expect. A transverse excision of the sac was now made just as close to the edges above and below as permitted by normal skin. Beginning at the ends of the ellipse, the skin with the subcutaneous tissue was dissected up each side toward the central longitudinal furrow until the membranes coming out of the canal were encountered. This membrane—*dura?*—was now followed into the wall of the cyst. On either side a good flap of it was obtained. There was very little bleeding

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and only such cerebrospinal fluid as was contained in the cyst was lost. A flap of lumbar fascia two inches long and wide as the erector spinæ was now raised from without inward on either side. The flaps at their bases blended with the flaps of dura. The dura flaps were overlapped and sewed together with interrupted mattress plain No. 0 catgut sutures. The fascial flaps were now turned backward till one overlapped the other and these also were matted together. A transverse incision was now made through skin and subcutaneous tissue about three inches from the upper edge of the defect, and the skin and fat between this incision and the defect were lifted up. Circulation in the flap was good, and the defect was closed by sliding this flap downward and suturing it to the skin at the lower edge of the defect. Subiodide of bismuth powder was sprinkled over the bare area and dry dressing applied. There was no shock. The baby was placed in bed in the same head-down position and fastened so. There was no leakage of cerebrospinal fluid. September 19 the child was discharged. The flap had healed in place. The defect was healing. There was total paralysis of limbs and sphincters. The baby thrived at home for a while, and then grew weak and developed gastro-intestinal symptoms and is reported to have died of malnutrition eight weeks after operation. It did not develop hydrocephalus.

CASE VII.—St. Mary's Infirmary, Reg. No. 56959, admitted January 31, 1925. Boy, seven weeks old. There is a hemispherical tumor three inches in diameter and about one and one-half inches in height, in the mid-line of the back, in the mid-dorsal region. The skin of the back covers its sides half-way to the summit, and here changes to a thin, semi-transparent, bluish-white pellicle in which dilated venules can be seen, and through which can be seen fluid somewhat translucent. At the summit the pellicle covering it is drawn in like a puckered dimple. It enlarges perceptibly when the baby cries. The tumor is said to have appeared some days after birth, and at first was thought by the physician to be a lipoma. The skin covering it was at first whitish, but has since become bluish. The X-ray failed to show the defect in the spine, although on palpation a distinct bony ring-like margin could be felt at the base. Because of the puckering or drawing inward of the skin at the summit, I expected to find some portion of the cord in the sac—meningomyelocele. The child was fretful and cried a great deal, but temperature was normal. There were no palsies noted. There were four other children, and all normal, and both parents were quite sure there had never been any deformities on either side.

*Operation.*—January 31, 1925. Ether. A transverse excision was done preserving as much normal skin as possible. The sac was opened in the mid-line half way to the summit before excising it. A structure about the size and shape of the baby cord was seen emerging from the canal, and which, proceeding to the summit of the sac, attached itself there at the site of the dimple mentioned. It could not be seen re-entering the canal, and although so high up (mid-dorsal), it was feared that there was a possibility of its being cord. The baby was allowed to revive from the anæsthetic, and it moved its legs freely even when I handled this process. Its tip was now carefully separated from the sac, and while doing this, the process broke, leaving a free portion attached to sac lining. On removing and sectioning it, we found it to be a cyst one centimetre in diameter and containing "cheesy" matter. Microscopic sections later showed "a skin-like structure with hyperplasia of sweat glands." The proximal fragment was removed, flush with the cord, and sections from this show "ganglion and glia cells."

The sac was cut away, leaving enough of the pedicle to close easily. No transplantation of fascia flaps was done, and the edges of the skin closed by undercutting and sliding. The child made an uneventful recovery. *Present condition.*—The child seems perfectly normal. There is a bulging at the site of operation, partly reducible. The skin slips over it. There is a hard mass about 1 to 1.5 centimetre at its edge that seems to be connected with the spine. The mass seems to have a pedicle.

*Comment.*—The interesting thing about this case was the peculiar cord-like process reaching from within the canal and attached to the roof of the



sac. That its inner end should resemble the structure of the central nervous system and its outer that of the skin is, of course, what one might have expected, since the deep portion of the sulcus vertebralis forms the central nervous system. The process found in the sac, I take it, was a complete cross-section of the lateral walls of the sulcus vertebralis, which remained unabsorbed. Perhaps, in fact, this unabsorbed remnant was the cause of the spina bifida, but why it was not absorbed has not yet been told.

**CASE VIII.**—St. Mary's Infirmary, Reg. No. 57195, admitted March 17, 1925. A healthy male, sixteen hours old. There were five other children all living and well. No deformities on either parent's side of the family. There are no paralyses of any kind. There is an enormous, somewhat spherical tumor attached by a pedicle to the mid-line of the back. The pedicle reaches from about lumbar 3 to sacral 3 (about two and one-half inches). The tumor is covered with dusky red skin, and many large veins can be seen on its surface. It is moderately tense, fluctuates on test, and seems to contain fluid. It is translucent throughout. It is quite five inches in diameter. Compression causes bulging of the fontanelle. No paralyses. Meningocele. It was decided to operate at once.

**Operation.**—The usual position, ether anaesthetic. The cyst was punctured and 625 cubic centimetres of cerebrospinal fluid were slowly withdrawn before the sac was empty. The sac was opened on its summit and a still further (estimated at thirty cubic centimetres) amount escaped. A transverse elliptical incision was made, including the pedicle. The skin was reflected and the pedicle exposed. Looking into the sac through the incision in its summit, one could see nerves lying in the open spinal canal at the bottom of the sac. Some of them were doubled up or folded upon themselves and some penetrated the pedicle wall below, escaping from the sac into the superficial tissue behind the sacrum. The pedicle was cut long enough so that its edges would a little more than meet each other in the mid-line. They were sewed together with continuous plain No. 1 catgut. Two flaps of fascia were now elevated (see Fig. 4), turned backward till one overlay the other, and sutured in this position with interrupted mattress sutures of No. 0 twenty-day catgut. Skin closed by sliding. (Fig. 5.)

By mistake the sutures were removed too soon and on the sixth day the wound reopened in the mid-line. However, by careful dressing and using 2 per cent. mercuriochrome freely and continuing the head-down position, infection was kept out and by April 12, 1925, the child was taken home completely well. The child at present is perfectly normal. No sign of hydrocephalus.

**Comment.**—While this is an example of meningocele, and although it was entirely covered with normal skin, it was of such a size that it most surely would soon have become traumatized or ulcerated. Nothing was to be gained by waiting and it is very well known by all who have had much experience with operations on babies that there is very little shock after operations done during the first hours of life.

**CASE IX.**—St. Mary's Infirmary, Reg. No. 60432, admitted November 10, 1926. A female baby, seventeen days old. Seems healthy. Has a rather large head—hydrocephalic?—but no bulging of fontanelles. The baby was normal delivery, full term, eight pounds. There is a tumor in the mid-line, in upper lumbar region. It is about three inches in diameter, circular in outline, and about one and one-fourth inches in height. The skin covering it is of a peculiar, purplish-red, and ascends half way to the summit, where it gives place to a thin, gray-white membrane. Along the mid-line at the summit over an area about 1.5 by 2.5 centimetres there is no epithelial covering. The surface here is granular and red in color and from this surface, occasionally, a drop of clear fluid comes. No opening can be seen. Pressure over the tumor is not felt over fon-



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tanelles—cystic myelocoele? The left lower limb has hung blue and paralyzed since birth. The right lower limb does not hang quite so lifeless and baby flexes right thigh occasionally. The sphincter ani appears to be normal. The mother's blood gives Wassermann test positive ++++.

It has been stated that hydrocephalus is a contra-indication to operation, but here was a child whose sphincters seemed normal, one entirely paralyzed and one partially paralyzed lower limb, whose head—while a trifle large—was not altogether hydrocephalic. It was decided to operate.

*Operation.*—November 19, 1926. For eight days a 1 per cent. mercurochrome was applied twice daily to the granular area. When we had the baby in the operating position, I painted the tumor and the field with half-strength tincture of iodine; this was removed with alcohol. Two per cent. mercurochrome was used to paint the granular area. With a sharp scalpel, I pared away the superficial layer of the granular area, working under a stream of saline at 104° Fahrenheit.

The incisions were now made above and below so as to remove the mass by transverse, elliptical excision, and saving just as much skin as possible. The tumor was freed to its pedicle all around. The sac was now opened to the right side of the granular area. This, as suspected, was the dorsal aspect of the cord. The sac wall was cut free from the cord all around the granular area referred to. No nerve roots ran in the sac wall; they could be seen disappearing into the shallow canal in the bottom of the sac. Enough of the pedicle was left to cover over the canal. The flaps of fascia were raised and turned back as usual, and the wound was closed with the Celsus flap in the usual way. The child recovered without incident, but was given active antiluetic treatment the while. After four days, we noticed movement in the left leg and it no longer "hung lifeless." There was also more motion in the right. The improvement was very marked at the time of the discharge of the patient. The sphincters continued normal. The hydrocephalus became more evident. In a month it was quite marked. Antiluetic medication failed to arrest its progress and the child died March 14, 1927.

CASE X.—St. Mary's Hospital, Reg. No. 27331, admitted September 21, 1927. A white boy baby, seven months old. There has been a tumor in the lower lumbar region since birth, but at the age of five months, the child developed whooping cough, and since then the tumor has been getting larger and discharging. The child was a normal delivery, and has been breast fed and is quite healthy and bright. There is no history of any kind of defect or deformity in the family. There are no paralyses of limbs or sphincters. There is a hemispherical tumor in the mid-line of the back, in the lower lumbar region. It is 6.5 centimetres in diameter and has an elevation of 5 centimetres. Its sides are covered with normal-looking skin. On the summit are two somewhat deep depressions. One in the mid-line below is funnel-shaped and its floor is lined with a pinkish granular surface which bleeds easily, and from its centre comes a clear, watery fluid. The second depression in the summit is 2 centimetres cephalad to the first, and 2 centimetres to the left. At the right edge of this depression, is what looks like a granulating surface 2 centimetres long by 1 centimetre wide, and from this comes clear fluid. The covering of the summit of the tumor is a thin, semitranslucent membrane, bluish-pink in color and is tense in spite of the fact that fluid is escaping. There are no paralyses. It was thought to be a cystic myelocoele.

*Operation.*—September 22, 1927. Under ether with the baby in the usual position, a transverse excision of the tumor was made. The incisions were made across the tumor, so as to retain all of the normal skin possible. The dissection was then made around the tumor so as to isolate the lower half of the tumor and its pedicle. The sac was now opened on its summit to the right of the mid-line, and its fluid contents—clear and watery—estimated at 100 cubic centimetres, escaped. The interior of the sac looked not unlike the inner surface of the normal dura. The bottom of the sac disappeared in the spinal canal, and, issuing from the canal, was seen a structure which looked like the end of the cord devoid of nerve roots and covered with a web-like membrane. This

structure was attached to the roof of the sac, under the funnel-shaped dimple in the mid-line, previously mentioned. The cord-like structure was cut free from the roof, and turned back into the spinal canal. It was necessary to remove the vertebral arch below the pedicle of the sac in order to do this without squeezing or crushing it. The pedicle of the sac was left just long enough so that its serous surfaces could be apposed in vertical mid-line closure. Two flaps of lumbar fascia, bases toward each other and as close as possible to edge of bony defect, and long enough to cover the defect, were turned over backward, one to overlap the other and close the defect. The usual sliding closure was then made. The recovery was uneventful and the child is at present quite normal in all respects.

*Comment.*—In this case, cerebrospinal fluid (?) had been escaping from the tumor for at least two months, and yet the child remained quite well. Other such are recorded by Fincham and Hoon. The structure projecting which "looked like the end of the cord devoid of nerves" perhaps should have been removed. Section through the roof at the place where this structure had been detached showed: "Tissue covered by squamous epithelium. The sub-epithelial tissue consists of granulation tissue, richly infiltrated with leucocytes and older hyalinized fibrous tissue. There are many lymph spaces which vary much in size and shape. (Arachnoid?)"

In my opinion, this is exactly the same sort of structure as that encountered in Case VII—namely, an unabsorbed "rest" derived from the walls of the neural groove. In this case it was found at the extreme end of the cord instead of in the mid-dorsal region, and more than likely was the filum terminale still canalized.

CASE XI.—St. Mary's Hospital, Reg. No. 281359, admitted April 3, 1928. A girl baby, well formed except for an abnormality in the lower part of mid-line of back, which consists of two portions, an upper hemispherical portion raised up to the extent of three-quarters of an inch and being about one and one-half inches in diameter. Attached to this and extending down from it, is a V-shaped trough, base formed by the above-mentioned tumor and apex extending to within two inches of anus. The V-shaped portion continues up and ends in a depression or dimple on the lower half of the tumor. This depressed, triangular area is red and glistening, looks like a congested mucous membrane, and from it is discharging clear fluid. The tumor is bluish-white. Its covering is a thin pellicle, semi-translucent. It becomes tense when the baby cries; also, the fluid flows more freely from the area when the baby cries. Between the tip of the reddish, triangular area and the anus, there is a deep depression (dimple) in the mid-line. The baby moves all of its limbs normally. There is no anal reflex. The baby voids urine from time to time, and although the anus has a loose feel, the bowel moves at intervals of perhaps three or four hours.

*Operation.*—April 3, 1928. The day before operation, the part was painted every three hours with 2 per cent. mercurochrome and kept covered with sterile gauze which was not allowed to become soiled. The preparation for operation consisted in painting the field with half-strength tincture of iodoine. This was removed with alcohol. Iodine was not applied to the raw surface, but 2 per cent. mercurochrome was used instead. Then with a sharp knife, while the baby was held in the head-down position, beginning at the highest point of the raw area, the surface of the raw area was pared away under a stream of sterile saline. A very thin area was removed, as is sometimes done in preparation for a skin graft. The tumor was incised and its interior inspected. It contained cerebrospinal fluid which escaped, when a mass could be seen apparently com-

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ing out of the canal of the spine and ending in the roof of the sac in the mid-line under the dimple already described. No nerves were seen. This structure was separated from the roof and returned to the canal. The hemispherical tumor mass was excised transversely and the triangular mucous surface was excised. This portion of the defect was closed vertically. The elliptical defect left after excision of the hemispherical tumor was closed by undercutting and making a flap in the usual way. The baby bore the operation very well and could move its legs as well after operation as before.

Nothing abnormal was noticed until the third day, when suddenly the legs became œdematous and petechial areas appeared around the upper thighs and lower abdomen, especially in front. At the same time, the baby did not take its food very greedily,



FIG. 6.—Case XI. A diagnosis of myelocoele was made. Notice that the trough-like, reddened area extends low down. Clear fluid came from the bottom of it. At operation, a structure which looked like the end of the cord, minus nerve roots, was found attached to the red area. The specimen has been lost. In all probability it was a persistent and open filum terminale.

and on the seventh post-operative day refused food entirely. The abdomen became distended. At this time the thighs were cyanotic. The baby cried a good deal. The pædiatrists were lavaging the stomach and doing their best to find a formula that would agree. Spinal fluid was discharging in moderate quantities (through the defect above) up until the seventh day, but the wounds were healing. Nothing abnormal was noticed about urine or bowel movements. The baby was being treated by lavage and gavage from the eleventh until the fifteenth, on which day there was no urine or defecation. Emesis began on the sixteenth. On this day also there was no bowel movement and no urine. On April 17 the patient died, fourteenth post-operative day.

The striking feature was the swelling of the lower limbs which had begun on the third post-operative day and grew worse until death. The first week the patient

was kept in the head-down position, but when cerebrospinal fluid no longer discharged, it was lowered to normal and lay on either side or abdomen.

A partial post-mortem was obtained and revealed a diffuse, foul-smelling general peritonitis, the cause of which was not determined, but there was a distended bladder with gangrenous cystitis, and at one point the bladder wall was so thin that fibrin was laid down on the peritoneum at this point (posterior superior surface). Cultures were made but were lost on the way to the laboratory.

CASE XII.—St. Mary's Infirmary, Reg. No. 63201, admitted June 4, 1928. A girl baby, ten months old. Since birth the feet have been "clubbed" (varus), and baby has not moved her legs properly. The child seems normal mentally. The head is large. The eye movements are normal and "the fundi show slight venous engorgement, and the disc edges are not clear" (Doctor Hardesty, ophthalmologist). The child can flex thighs on the abdomen. Asleep, she lies on the right side with thighs almost at a right angle with the body, and knees in extension. She can slowly move the right knee and foot slightly, but the whole left lower limb is paralyzed. Response to pin prick and light touch is negative in the left leg and thigh, and seems less than normal in the right. The sphincters are incontinent. The anus gapes. The baby's color is good, and it is well nourished. There is a tumor, somewhat hemispherical, in the mid-line of the back in the mid-lumbar region. It is about 5 centimetres by 5 centimetres, and is elevated about  $\frac{3}{4}$  centimetre. Its surface looks like scar tissue, and is much furrowed. The skin covering the summit is bluish and thin-looking. The tumor has a lumpy feel, is compressible, but not reducible, becomes tense when the child cries, but does not pulsate. A few coarse hairs are seen around its base. An X-ray of the spine reveals a defect in the third and fourth lumbar vertebral arches. There is a slight enlargement of the skull and convolutional impressions are deepened. The other three children in the family are healthy. The Wassermann (cerebrospinal fluid) is positive.

*Operation.*—June 4, 1928. A transverse excision removing an ellipse of skin with the tumor in the centre. (See Fig. 2.) The pedicle of the sac was left long enough so that its edges could be approximated in a vertical suture. The pedicle is thick and fibrous, and is about one inch in vertical, and slightly less in transverse diameter. The sac contains clear fluid and a fibrous, cord-like structure—*filum terminale*?—issues from the canal and joins the roof of the sac in the mid-line below the centre of the summit. Neither cord nor nerves were seen. There was a quantity of peculiar, fibrofatty tissue outside the pedicle. The sac was cut away and the opening was closed by suturing the pedicle edges together vertically and then two flaps were raised from the lumbar aponeurosis, and turned over backward, the edge of one made to overlap that of the other. The skin and subcutaneous tissue closed in the usual way by sliding down a flap from above. The child made an uneventful recovery, and was discharged July 5, 1928.

Present condition unknown.

*Comment.*—This child seemed to acquire more use of its legs after the operation, but I could not be entirely sure whether the movements were voluntary or reflex. There was no recovery in the sphincters. The mentality remained bright, and the child seemed quite well in other respects.

#### SUMMARY

The records of all the author's cases up to 1929 are given—twelve cases. There was one operative death(?). The child developed cystitis and peritonitis and died on the fourteenth day.

The ages varied from sixteen hours to seven months. There were seven females and five males.

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There were five myeloceles, four meningo-myeloceles, and three meningo-celes. Eight "open" (discharging cerebrospinal fluid) and four were closed.

Five showed sphincteric paralyses before operation. The same has not been benefited by operation. Six (including the above five) have had more or less paralyses in the extremities. In one there was thought to be improvement after operation. In one the paralysis was made worse.

Three were markedly hydrocephalic—one died in four months; one is alive and alert, seven years old. No child has developed hydrocephalus since operation.

Eight of the twelve are living and well, three are dead, and one could not be traced.

The author is of the opinion:

1. That by rigidly following the technic outlined, the operative mortality should be *nil*.
2. That an open sac alone is no contra-indication to operation.
3. That the diagnosis of myelocele does not always contra-indicate operation. The diagnosis may be wrong when the defect is in the lumbosacral region.
4. That a total paralysis of the sphincters, in the presence of a myelocele, is a distinct contra-indication to operation.
5. That in meningo-myelocele the only way to be certain with regard to the presence of the cord in the sac is to open and look within it.
6. That the children under four days old stand the operation best.
7. That there is no need to make any kind of osteoplastic reconstruction of the spinal canal.
8. That paralyses with certain cases of meningo-myelocele are improved by operation.

## BIBLIOGRAPHY

- Abbe, R.: Spina Bifida. International Clinics, Series 2, vol. iv, p. 209, Philadelphia, 1893.
- Babcock, Wayne: Spina Bifida and Its Surgical Treatment with a Description of an Efficient Osteoplastic Operation. Month. Cyclopedia and Med. Bul., vol. iv, p. 257, 1911.
- Baldwin: The Artificial Production of Spina Bifida. Anat. Rec., vol. ix, p. 365, 1915.
- Bobroff: Ein Neues Osteoplastisches Verfahren bei Spina Bifida. Centralb. f. Chir.; Bd. xix, s. 465, 1892.
- Cleland: A Contribution to the Study of Spina Bifida. Jour. of Anat. and Physiol., vol. xvii, p. 257, London, 1883.
- Coffey, R. C.: Production of Aseptic Uretero-enterostomy. Jour. Am. Med. Ass'n., vol. xciv, p. 1748, 1930.
- Cruveilhier: Traite d'Anatomie Pathologique, Générale, vol. i; pp. 201 and 598; also vol. iii, pp. 453 and 654, Paris, 1849.
- Cutler: End-Results in Sixty-two Cases of Spina Bifida and Cephalocele. Arch. Neu. and Psychiat., vol. xii, p. 149, 1924.
- Dareste: Sur l'Influence des Vapeurs Mercurielles sur le Developpement de l'Embryon. Comptes Rendus à la Société de Biologie de Paris, vol. xlv, p. 683, 1893.
- Dollinger: Die Osteoplastische Operation der Spina Bifida. Wien. Med. Woch.; Bd. xxxvi, s. 1535, 1886.



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- Eastman, J. R.: Operative Technic in Spina Bifida. *Jour. Am. Med. Ass'n*, vol. lxxiv, p. 156, 1920.
- Ecker, A.: Äussere Formen Jungster Menschlicher Embryonen. *Arch. für Anat. u. Entwickl.*, s. 143, 1880.
- Féré: Sur l'Influence de la Lumière et des Injections Chimiques sur l'Incubation des Œufs de Poule. *Comptes Rendus à la Société de Biologie de Paris*, vol. xlv, pp. 744, 787, 849, 852, 1893.
- Fincham: Case of Spina Bifida—Ulceration—Escape of Cerebrospinal Fluid and Recovery. *Br. Med. Jour.*, vol. ii, p. 1180, 1897.
- Förster: Die Missbildungen des Menschen. *Rückenmarksbruch*, p. 84, 1861.
- Froelich: Is it Necessary to Operate in Spina Bifida? *Agrégé of Nancy, France; Med. Press and Circa*, vol. cxlvii, p. 496, London, 1913.
- Harmer: Spina Bifida and Allied Malformations Based on an Operative Experience of Thirty-four Cases. *Bost. Med. and Surg. Jour.*, vol. clxxvii, p. 353, 1917.
- Harrar, Jas. A.: Spina Bifida in the New Born. A Report of All Cases in New York Lying-In Hospital. *Bul. Lying-In Hosp., N. Y.*, vol. x, p. 143, 1916.
- Hildebrand: Pathologische Anatomische und Klinische Untersuchungen zur Lehre von der Spina Bifida. *Deutsch. Zeitsch'ft f. Chir.*, Bd. xxxvi, hft. 14, p. 433, 1893.
- Homans, John: A Text-Book of Surgery by Members of the Surgical Department of Harvard Medical School. C. C. Thomas; First edition, p. 729, 1931.
- Hoon: Cure of a Case of Spina Bifida. *Jour. Am. Med. Ass'n*, vol. xlv, p. 39, 1905.
- Humphrey: The Anatomy of Spina Bifida—A Museum Lecture. *Lancet*, vol. i, p. 557, London, 1885.
- Keiller, V. H.: A Contribution to the Anatomy of Spina Bifida. *Brain*, vol. xlv, p. 31, 1922.
- London Clinical Society: Report of the Society's Committee Nominated November 10, 1882, to Investigate Spina Bifida and Its Treatment by Injection of Doctor Morton's Iodo-Glycerine Solution. *Transactions Clin. Soc. Lond.*, vol. xviii, p. 339, 1885.
- Mall: Congenital Malformations. *Jour. of Morph.*, vol. xix, p. 9, 1908.
- Moore, J. E.: Spina Bifida, with a Report of Three Hundred and Eighty-five Cases Treated by Excision. *Surg., Gynec., and Obstet.*, vol. i, p. 137, 1905.
- Morgan, F. H.: Effects Produced by Centrifuging Eggs Before and During Development. *Anat. Record*, vol. iii, p. 155, 1909.
- Panum, P. L.: Beiträge zur Kenntniss der Physiologischen Bedeutung der Angeborenen Missbildungen. *Virch. Archiv.*, Bd. lxxii, s. 69, 1878.
- Ranke: Zur Aetiologie der Spina Bifida. *Jahrbuch für Kinderheilkunde*. Bd. xii, s. 116, 1878.
- Ranson: Development of the Neural Tube in the Human Embryo. *Anatomy of the Nervous System*, p. 30, Saunders Pub. Co., 1927.
- Rindfleisch, Ed.: Die Angeborene Spaltung der Wirbelkörper. *Arch. für Path. Anat.*, Bd. xix, s. 546; also Bd. xxvii, s. 137, 1863.
- Romanis, and Mitchiner: Science and Practice of Surgery. William Wood and Co., Second edition, vol. ii, p. 109, 1929.
- Saint-Hilaire, Isidore Geoffroy: Histoire des Anomalies—Fissure Spinale. Vol. i, p. 614, 1832; also vol. ii, p. 365.
- Tourneux, et Martin: Contribution à l'Histoire du Spina Bifida. *Jour. de l'Anatom. et de la Physiol.*, vol. xvii, p. 1, Paris, 1881.
- Von Recklinghausen: Untersuchungen über die Spina Bifida. *Virch. Archiv.*, vol. cv, hft. 15, p. 243, 1886.
- Von Bayer: Zur Technic der Operation der Spina Bifida. *Präger Med. Woch'sch'ft*, vol. xvii, No. 28, p. 317, 1892; also, No. 29, p. 332.
- Von Bergmann: Spina Bifida. *International Clinics*, Ninth series, vol. ii, p. 161, Philadelphia, 1899.

## BRILLIANT GREEN

A CLINICAL STUDY OF ITS VALUE AS A LOCAL ANTISEPTIC

By JOSEPH K. NARAT, M.D.

OF CHICAGO, ILL.

FROM THE NORWEGIAN-AMERICAN AND LUTHERAN MEMORIAL HOSPITALS

AN IDEAL local antiseptic must meet several requirements and possess the following properties:

1. Great inhibitory power toward pathogenic microorganisms, at least those which are most important and most frequently encountered in common surgical diseases; this antiseptic property must be exhibited not only *in vitro* but also *in vivo*, i.e., in the presence of serum.
2. Rapidity of action, in order to prevent spreading of infection.
3. Sufficient penetrating power.
4. No deleterious effects on phagocytosis, products of glandular secretion, hormones and other defensive processes of the organism.
5. Absence of irritating effects, even after repeated applications upon the tissues of the host, including delicate and sensitive structures such as mucous membranes.
6. No interference with or a stimulating effect upon reparation processes of the organism, particularly formation of granulation tissue.
7. Low toxicity in case of absorption.

Generally speaking the local antiseptics can be divided into two groups: (1) Those which are not irritating and injurious to the tissues but have an extremely low germicidal action. (2) Those which are powerful disinfectants but at the same time damage the tissues. Their action as irritants arises from the same qualities as their bactericidal or bacteriostatic power, namely from general toxicity to the living matter.

Certain objectionable characteristics confine the justifiable application of most of the popular antiseptics to within narrow limits. For instance, acriflavin has won favor because of its penetrating action and the length of its activity, but it is not a particularly rapidly acting antiseptic. This fact lessens its value for prophylactic treatment of potentially infected wounds. Hexyl-resorcinol gave growth of bacteria in all tests carried out by Raisiss and Severac.<sup>1</sup> Tincture of iodine has the disadvantage of causing irritation of the skin in many patients, particularly if wet compresses have to be applied after painting with iodine. Tinker and Sutton<sup>2</sup> found that iodine, trinitrophenol, Harrington's mercuric chloride solution, mercurochrome—220 soluble—and potassium mercuric iodide will not kill most of the resistant bacteria and some of the less resistant pathogenic bacteria under conditions of perfect contact.

It is exceedingly difficult to estimate the value of an antiseptic in the

prevention or treatment of septic processes because the innumerable bacteriological tests at our disposal are all subject to criticism; hence the reports are confusing and contradicting. Practically speaking, the only method to judge an antiseptic, after its bactericidal action has been ascertained in preliminary antiseptic and toxicity tests, is to evaluate the clinical results obtained and to compare them with results observed after use of other known disinfectants.

The fact that new antiseptics and germicidals make their appearance in the literature and on the market serves as best proof that most of the substances in general use fall short of the ideal in their therapeutic action. The popularity of some of the newer antiseptics is not based entirely upon their merits but is due partially to the wide publicity and undiscerning enthusiastic reports.

On the other hand, some valuable old antiseptics have been overlooked or fallen into misuse either because they have not been made the subject of extensive clinical studies or because they did not represent products of high commercial value. One of the most powerful among such antiseptics is brilliant green. The bacteriostatic action of certain dyes on bacteria was observed as early as 1887. Browning, *et al.*<sup>3</sup> recommended the use of brilliant green in 1917; they found that the substance is particularly destructive to the cocci group but toward bacterium coli its bactericidal value is considerably lower. Krumwiede and Pratt<sup>4</sup> found that the inhibition of growth by brilliant green has been most evident among the Gram-positive bacteria; the paratyphoid enteritidis types are more resistant. Ligat<sup>5</sup> reported very satisfactory results with brilliant green. Peterson<sup>6</sup> studied the comparative merits of various antiseptics by recording their inhibiting effect upon the yeast-sugar mixture. The method consists in determining the smallest quantity of drug that will prevent the formation of gas in a yeast-sugar mixture of definite strength during a period of one hour. Whereas the inhibitory amount of metaphen in grams was 0.0017 and that of mercurochrome 0.065, the amount of gentian violet was only 0.0039, crystal violet 0.0024 and methyl violet 0.0051. These figures show that the above-mentioned aniline dyes possess a much stronger inhibitory power than mercurochrome and compare very favorably with metaphen. Another dye, however, is still superior to these aniline dyes as far as bactericidal action is concerned and this is brilliant green as shown by the experiments carried out by Norton and Davis<sup>7</sup> who determined the bacteriostatic action of dyes on streptococcus viridans and pneumococci. They state that brilliant green is the most active dye they found, as evidenced from the following part of their protocol:

Dye	Slightest dilution giving complete inhibition
Brilliant green .....	200,000
Gentian violet .....	40,000
Methylene blue .....	25,000
Methyl violet .....	10,000

According to their statement to have a marked bacteriostatic action, a dye must contain three benzol rings and two or more amino-groups in which the

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hydrogen atoms have been substituted by alkyl radicals. In most instances this alkyl radical is the methyl group but in brilliant green ethyl groups are present.

Disregarding the excellent qualifications, brilliant green has fallen into oblivion and the interest in it was revived by Doctor Baccal,<sup>8,9</sup> the scientific collaborator of the surgical clinic of the State Institute of Odessa. He limited his report to general statements as to the great value of brilliant green in minor surgery, pre-operative preparation of the skin, sterilization of hands, catgut and surgical instruments and treatment of burns and certain external eye diseases, such as blepharitis.

In view of the above-mentioned laboratory experiments and favorable clinical reports by Browning, Ligat, Baccal and others, a further investigation of the qualities of brilliant green seemed to be justified. The present study was limited to evaluation of brilliant green as a local antiseptic.

Brilliant green chemically is a diamino-triphenylmethane compound. The product is a green powder, soluble in water and alcohol; the aqueous solution is not stable and should be freshly prepared; it has been used by me only for warm baths and compresses. Otherwise a 1 per cent. solution in 60 per cent. alcohol was used in all the cases except mucous membranes where 0.5 per cent. solution seemed to be more advisable. The stains on hands can be removed by vigorous rubbing with alcohol or hydrogen peroxide; the latter can be used to remove stains from soiled linen, but usually the ordinary washing processes are sufficient.

As space prevents a detailed report of all cases treated, a brief résumé shall be made of the clinical results obtained. The treatment was either prophylactic or therapeutic.

*A. Prophylactic Treatment with Brilliant Green.—1. Pre-operative Preparation of the Skin: a. Minor surgery.*—Unless exceptionally dirty when a preliminary washing with soap and water was necessary, no preparation of the skin except painting with 1 per cent. brilliant green solution was made in order to form a better judgment as to the antiseptic power of the product. Operations were performed for such conditions as subcutaneous lipomas, fibromas, cystomas of the tendon sheaths, sebaceous cysts, phimosis, etc. In infants 0.5 solution was used instead of 1 per cent. solution. The results obtained in this group were very satisfactory. In the whole series of ninety-three cases there was not a single occurrence of infection. The great susceptibility of the tendon sheaths to infection is well known; nevertheless in seven cases of ganglion of the tendons no infection occurred. An irritation of the skin could not be observed in any of the above-mentioned cases.

*b. Major Surgery.*—After the favorable results obtained in the pre-operative treatment of minor cases, the use of brilliant green in major surgery seemed to be justified. After the routine preparation, consisting of washing with soap and water, followed by alcohol, a 1 per cent. alcoholic solution of brilliant green was used for the pre-operative preparation of the skin in laparotomies for various conditions. The results were highly satisfactory.

No infections were observed which could be ascribed to the use of brilliant green. In one case a stitch abscess occurred which could be traced to contaminated catgut. Not in a single case in the series of 111 were there any indications of irritation of the skin, even when wet compresses had to be applied afterward. The use of brilliant green should be of special value in the pre-operative preparation of the skin for thyroidectomies where absorption of the tincture of iodine is feared. A 0.5 per cent. solution was used on mucous membranes for hemorrhoidectomies, vaginal repairs, suturing of lacerated lips and similar conditions.

2. *Prophylactic Treatment* of potentially infected wounds and abrasions including minor injuries as well as extensive lacerations which came under treatment a very short time after injury and where no clinical signs of infection were yet present. There is no positive criterion to judge the efficiency of an antiseptic in such conditions and in forming an opinion one is guided by impressions rather than by definite figures. An opportunity presented itself, however, in a case of laceration of several fingers to investigate the comparative value of metaphen, mercurochrome and brilliant green. All seven injured fingers presented approximately the same degree of injury of soft parts and were equally contaminated with dirt and machine oil. The two wounds treated with metaphen showed no signs of infection and produced granulations of a pale pink color; the healing process was fairly rapid; three fingers treated with mercurochrome produced pus and showed brownish granulations of moderate size with very slow healing tendencies; in two fingers treated with brilliant green a rapid formation of exuberant, bright-red granulations could be observed which led to a scar formation more quickly than in the other fingers. Of course, such an experiment is not conclusive as to the relative value of various antiseptics as it may be argued that the degree of infection of each injured finger could not be exactly determined; nevertheless the striking results are in line with experiments of Browning, *et al.*,<sup>3</sup> who also observed in a large number of cases that brilliant green stimulates the formation of richly vascularized red granulations while with flavine the granulations were not so bulky and of pale color. No indications of tissue damage or irritation could be observed.

B. *Therapeutic Treatment*.—This category comprises 123 cases which already exhibited manifest infection when they presented themselves for treatment. This group comprises such spastic conditions as abscesses located in various parts of the body, including Bartholini's abscesses and post-operative stitch abscesses; acute suppurative bursitis; acute suppurative lymphadenitis; boils; carbuncles; phlegmons, cellulitis; fistulæ resulting from osteomyelitis. In addition to the painting of the skin with brilliant green solution before the incision was made, the solution was also instilled into the wounds at each dressing. In a number of cases this treatment was supplemented by bathing the infected part in a warm aqueous solution of brilliant green 1:2000 and compresses of an aqueous solution 1:1000. In ischio-rectal and perianal abscesses the results appeared to be superior to mercuro-



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chrome but to an impartial eye they were not better than those obtained with acriflavine and especially with metaphen; the same observation was made in abscesses after appendectomies and in cold abscesses. This fact is probably due to the above-mentioned limitations of the bactericidal properties of brilliant green. As stated, this chemical is very efficient in all cocci infections but its antiseptic power is much smaller toward bacterium coli and tubercle bacilli. In the rest of the cases the results ranged from very satisfactory to excellent.

*Discussion.*—The clinical results with brilliant green solution as local antiseptic showed that the product was efficient as a prophylactic measure against infection in the pre-operative preparation of the skin. In the treatment of infected wounds and various septic processes the impression was gained that the infection was more quickly brought under control, the granulations were more abundant and healthier and the healing process was more rapid than has been the author's experience with other antiseptics in general use. As to the toxicity, no ill effects following the use of this substance over prolonged periods of time could be observed. It is left to the genito-urinary specialists to decide whether a clinical trial with brilliant green in the treatment of gonorrhœa is desired. As to the intravenous injections, extensive laboratory experiments will be necessary. The use of brilliant green for sterilization of the hands of the surgeon as advocated by Baccal will hardly become popular in view of the staining properties of the substance. The attempt to use it in preparation of catgut may be justified although several manufacturers asserted to the author that there is no need for introduction of a new antiseptic in preparation of catgut as the present methods are satisfactory. A recent report by Meleney and Chatfield<sup>10</sup> shows that in a study of 174 specimens of catgut submitted by twelve surgical clinics, twenty-two or 12½ per cent. were found to yield spore-forming bacteria including the common gas gangrene organisms. In this connection it may be interesting to note that according to Churchman<sup>11</sup> who studied the bacteriostatic action of gentian violet upon bacterium anthracis, the spores are at least gravely affected by treatment with the dye and that in presence of it they can not develop. As brilliant green has a higher bacteriostatic action than gentian violet, the use of it may be of value in preparation of catgut. A ¼ per cent. ointment prepared by dissolving brilliant green in water and mixing it with petrolatum has been recommended by Baccal for treatment of burns.

### SUMMARY

A survey of the clinical results after the use of brilliant green as local antiseptic in prophylaxis as well as treatment of various surgical conditions shows that the substance possesses a high antiseptic value toward the most frequent pathogenic microorganisms encountered in surgical diseases; it has an excellent power of penetration; it is non-irritant and non-toxic; it stimulates the formation of healthy granulation tissues and, last but not least, it is

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very cheap. The impression was gained that in many instances the substance was superior to other antiseptics in common use. These findings justify further clinical investigations as to the value of brilliant green and suggest the desirability of laboratory experiments in order to evaluate it as a general antiseptic.

LITERATURE

- <sup>1</sup> Raisiss, G. W., and Severac, M.: J.A.M.A., vol. xciv, p. 1199, April 19, 1930.
- <sup>2</sup> Tinker, M. B., and Sutton, H. B.: J.A.M.A., vol. lxxxvii, p. 1347, October 23, 1926.
- <sup>3</sup> Browning, C. H., Kennaway, E. L., Gulbransen, R., and Thornton, L. H. D.: Brit. Med. J., vol. i, p. 73, January 20, 1917.
- <sup>4</sup> Krumwiede, Ch., and Pratt, Josephine S.: J. Exp. Med., vol. xix, p. 501, 1914.
- <sup>5</sup> Ligat, D.: Brit. Med. J., vol. i, p. 78, January 20, 1917.
- <sup>6</sup> Peterson, Joel B.: J.A.M.A., vol. lxxxvii, p. 223, July 24, 1926.
- <sup>7</sup> Norton, J. F., and Davis, G. E.: J. of Inf. Dis., vol. xxxii, p. 220, 1923.
- <sup>8</sup> Baccal, S. A.: J.A.M.A., vol. xcv, p. 215, July 19, 1930.
- <sup>9</sup> Baccal, S. A.: Naukova Dumka. Pamphlet in Ukrainian, 1930.
- <sup>10</sup> Meleney, F. L., and Chatfield, Mabel: S., G. and O., vol. lii, p. 430, February 15, 1931.
- <sup>11</sup> Churchman, J. W.: J. Exp. Med., vol. xvi, p. 221, 1912; vol. xvii, p. 373, 1913.

## SOME INDICATIONS FOR SECTION OF THE POSTERIOR ROOT OF THE TRIGEMINAL NERVE THROUGH THE POSTERIOR FOSSA

BY WILLIAM P. VAN WAGENEN, M.D.  
OF ROCHESTER, N. Y.

FROM THE DEPARTMENT OF SURGERY, NEUROSURGICAL DIVISION OF THE UNIVERSITY OF ROCHESTER

SECTION of the posterior root of the trigeminal nerve through the temporal fossa has, by most clinics, come to be accepted as the usual route for carrying out this measure. It is well standardized and carries about as low a mortality and morbidity as any operation in surgery. There are, however, a group of cases where it would seem to be well-nigh impossible or at least extremely difficult to section the posterior root of the fifth nerve in this usual manner. It seems worthwhile to report a group of such cases—five in number. Dandy<sup>1</sup> has called attention recently to the feasibility of sectioning the posterior root of the trigeminal nerve through the posterior fossa. This operation has been carried out in the five reported cases as well as in a number of others.

CASE I.—*Trigeminal neuralgia, major—right. Section of posterior root of trigeminal nerve through posterior fossa because of an osteoma in the floor of the temporal fossa.* O. H., hospital No. 28,440, a thirty-nine-year-old woman, was referred to the hospital for the relief of major trigeminal neuralgia. The history was entirely typical of this malady and she was observed in several very characteristic attacks.

*Operation.*—The floor of the middle fossa of the skull was exposed by a linear incision through the right temporal muscle and elevation of the dura was carried medially for about three centimetres. At this point there was a fairly marked elevation of the floor of the middle fossa which seemed unusual. It apparently was situated slightly anterior and lateral to the foramen spinosum. An attempt was made to locate the foramen spinosum and divide the middle meningeal artery, but this proved impossible owing to the fact that this bony prominence projected upward to the height of about one centimetre in front of the foramen. An attempt was made to chisel this bony prominence away, but mucous membrane of the nasal cavity was at once exposed. The dissection was carried forward until the first division was identified, but it was impossible to expose enough of the ganglion to extirpate it. Consequently the attempt was abandoned, and on the next day the posterior root of the right trigeminal nerve was divided through the posterior fossa without difficulty. The motor root could be identified slightly anterior and medianward to the sensory root and was preserved. No particular difficulty in bleeding was encountered from the petrosal veins. The patient made an uneventful recovery and has had complete relief of pain to date, some eighteen months later.

CASE II.—*Basal-cell carcinoma of left cheek. Metastases to parotid gland and left temporal region. Section of trigeminal root through posterior fossa because of infection in temporal region.* J. P., hospital No. 26,048, was transferred to the neurosurgical service because of severe pain in the distribution of the left trigeminal nerve. He had been under treatment for over a year with a progressive basal-cell carcinoma

<sup>1</sup>Dandy, Walter E.: An Operation for the Cure of Tic Douloureux. Partial Section of the Sensory Root at the Pons. Arch. Surg., vol. xviii, p. 687, 1929.

of the face. Metastases to the parotid gland and temporal region had occurred. Biopsy of a gland in the temporal region had been done, and at the time seen the field was slightly infected. Because of the presence of tumor in the operative field and also because of the presence of infection it was thought advisable to section the posterior root of the trigeminal nerve through the posterior fossa. This was carried out under novocaine and colonic ether anaesthesia. There was some difficulty in exposing the trigeminal dorsal root owing to the fact that a large petrosal nerve lay directly over it and a small artery to the side of it. The artery was coagulated and divided. It was then possible to slip a hook beneath the vein and avulse the posterior root without damaging the motor division or tearing the petrosal vein. The patient had complete anaesthesia in the distribution of the fifth nerve. (Fig. 1 and Fig. 2.)

CASE III.—*Carcinoma of the jaw with cervical metastases. Section of the posterior root of trigeminal nerve through the posterior fossa in order to combine cervical dorsal rhizotomy with section of the root of the fifth nerve.* G. G., hospital No. 26,597, a



FIG. 1.

FIG. 1.—Case II. Basal-cell carcinoma of face. Metastases to temporal region and parotid gland which base became infected following biopsy.



FIG. 2.

FIG. 2.—Case II. Type of incision used for unilateral cerebellar exposure and section of dorsal root of trigeminal nerve via posterior fossa.

forty-seven-year-old man, was transferred to the neurosurgical service because of severe pain from carcinoma of the right jaw with metastases to the floor of the mouth and cervical lymph-nodes. When first seen most of the pain was largely in the region of cervical metastases. A section of the cervical nerves as they appeared along the posterior border of the sternocleidomastoid muscle was done rather than an intradural dorsal-root section, because of his poor general condition. At the same time a ligation of the external carotid artery was carried out because of the danger of hæmorrhage from ulcerations within the oral cavity. The patient obtained considerable relief from pain for about six months and was able to eat and sleep moderately well. At the end of this time, however, he had a recurrence of the pain both in the distribution of the cervical nerves and of the right trigeminal nerve. Opiates by this time had proven to be of little use and some more radical measure for relief of pain seemed warranted. Under colonic ether and local anaesthesia, the right trigeminal nerve was exposed through the posterior fossa. There were two good-sized branches of the petrosal veins lying over

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the nerve. These were electrocoagulated and divided. Another branch passed so close to the posterior root that it was impossible to divide it, and consequently both vein and posterior root were coagulated together. The dorsal root was not actually divided. At the same time the upper four cervical nerves were exposed by a hemilaminectomy and divided.

Complete anaesthesia over the face and cervical region of the operated side resulted. The patient survived ten days following operation. Autopsy showed a carcinoma of the right side of the tongue, of the right jaw, and of the floor of the mouth. A bilateral necrotizing pneumonia and gangrene of the lungs with multiple small abscesses presumably followed aspiration from a much-infected oral cavity.

CASE IV.—*Carcinoma of sphenoid sinus with extension to left Gasserian ganglion and basal dura mater.* Section of dorsal root of fifth nerve through posterior fossa. A. S., No. 31,209, a man aged fifty-seven, was referred to the neurosurgical service because of pain in distribution of the left fifth nerve. The patient obviously had Paget's disease

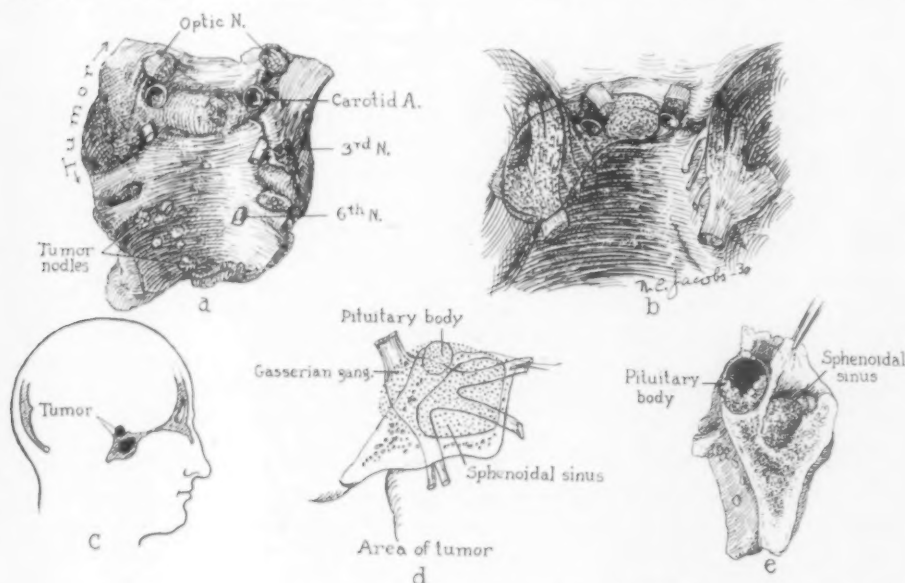


FIG. 3.—Case IV. Drawing of autopsy specimen showing invasion of left Gasserian ganglion, pituitary body and dura mater over basilar bone by a carcinoma of the sphenoid sinus.

in a fairly advanced stage. X-rays of the skull showed the usual changes associated with Paget's disease. The possibility of bony exostoses about cranial nerve foramina as a cause of the third, fourth, fifth and sixth nerve palsies was considered. A tumor of the Gasserian ganglion was also thought likely because of ocular palsies and pain in fifth nerve distribution along with partial anaesthesia and partial motor paralysis of that nerve. No evidence of a tumor involving the nasal sinus could be demonstrated by X-ray, probably because of the marked changes in bone associated with Paget's disease.

An attempt was made to section the posterior root of the fifth nerve through the middle fossa. The middle meningeal artery was exposed without difficulty. When an attempt was made to push bone wax into the foramen spinosum to control bleeding, the bone proved to be so soft that it pushed away in front of an instrument with great ease. Troublesome bleeding from the artery resulted, and it was necessary to ligate the external carotid artery in the neck. The middle meningeal artery was then divided. It proved totally impossible to expose the posterior root of the trigeminal nerve owing to the presence of a tumor of fairly great vascularity involving the Gasserian ganglion. After repeated unsuccessful attempts to extirpate enough tumor to get at the posterior



root, each associated with fairly profuse bleeding, the wound was closed. Several days later the posterior root of the fifth nerve was divided through the posterior fossa. The patient succumbed some six days later. Autopsy revealed the presence of a small carcinoma of the sphenoid sinus with extension to the pituitary gland, sphenoid bone, left Gasserian ganglion, and the dura mater at the base of the skull. (Fig. 3.) He also had moderate bilateral bronchopneumonia, arteriosclerotic kidney, healed pulmonary tuberculosis, and chronic, adhesive pleuritis. Changes in bone commonly associated with Paget's disease were everywhere evident.

*CASE V.—Trigeminal neuralgia—major. Section of posterior root of trigeminal nerve through posterior fossa because of dense adhesions between dura mater and Gasserian ganglion.* R. H., a forty-one-year-old man, was referred to the hospital because of severe trigeminal neuralgia of some ten years' duration. He had had nine or ten "deep alcohol injections," only two of which had given any lasting benefit.

*Operation.*—An attempted section of the dorsal root of the trigeminal nerve through the temporal fossa was made with the patient in the sitting posture. The middle meningeal artery was divided without difficulty. From this point on the dissection to uncover the dorsal root was extremely difficult. The dura was leather-like and so densely adherent to surrounding structures that it could not be elevated from over the dorsal root. The mandibular division of the ganglion and dura over it seemed fused. The ophthalmic division of the ganglion was then exposed and attempt made to uncover enough of the ganglion itself to either inject it or extirpate it. This also proved impossible. Presumably the previous stray alcohol injections had set up a profuse connective tissue reaction about the dura and surrounding structures.

Two days later the posterior root of the trigeminal nerve was exposed through the posterior fossa. The arachnoid about the nerve was much thickened and adherent to surrounding structures. Several fair-sized radicles of the petrosal veins gave troublesome bleeding and it was only after a long tedious procedure that the dorsal root was finally divided. The patient has had complete relief of pain but has had some persistent ataxia of one arm, presumably due to damage to the cerebellum in exposing the dorsal root and controlling bleeding.

The operative procedure has varied greatly in its technical difficulties. In three of the reported cases the trigeminal dorsal root was sectioned with comparative ease. In one case it was necessary to electrocoagulate the root along with a branch of the petrosal vein. The root could not be divided without a great likelihood of tearing the vein. On the other hand, complete anaesthesia and relief of pain followed such a procedure. In one case serious bleeding from a torn petrosal vein occurred and was controlled only with difficulty. Evidence of slight but permanent damage of the cerebellar lobe has resulted. In none of the cases has there resulted any injury to an adjoining nerve. The operation has been performed on five other patients where the dorsal root could have been sectioned through the temporal fossa. In two of these cases the root was only partially sectioned. In both of these cases the pain has been completely relieved. Sensory examination following this is in accord with that described by Dandy, *i.e.*, there was a preservation of normal sensation over the distribution of the trigeminal nerve except for a small area about the upper lip in one instance and about the lower lip in another. The impression gained from these ten cases is that the operation is a procedure of considerably greater magnitude and risk than that through the temporal fossa. In spite of this, familiarity with the operation would

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seem to be a very valuable adjunct to one's neurosurgical armamentarium. Two deaths in the ten cases operated on have occurred. Both were in subjects much debilitated by far-advanced carcinoma and death might well have followed any major surgical procedure. There is a group of cases where the trigeminal root cannot be sectioned through the temporal fossa and for these it would seem to be largely indicated. There is a second though smaller group where it is at times advisable to combine an upper cervical dorsal rhizotomy with section of the trigeminal root. This may well be combined in one operation.

The emphasis that Dandy has laid on a very exacting equipment, such as suitable lighted retractors, nerve hooks and right-angle knives, right-angle silver clip holders, a smooth anæsthesia, *etc.*, can only be stressed.

No difference in the type or distribution of sensory loss could be made out from that obtained by section of the dorsal root through the temporal fossa if the root was totally divided. In two cases where the dorsal root was partially divided there resulted a preservation of normal sensation over the greater part of the face. Preservation of the motor root has undoubtedly been easier and more assured by the posterior fossa route than by the temporal route.

### CONCLUSIONS

Five cases are reported where section of the posterior root of the trigeminal nerve was done for the relief of pain perforce of necessity. In one of these cases the operation was combined with a unilateral upper cervical dorsal rhizotomy. The impression is gained from these and other cases that while the operation is considerably more hazardous and difficult than that through the temporal route, it is a valuable adjunct to one's neurosurgical armamentarium. No evidence has been gained from this series of cases that the type or area of anæsthesia differs from that which occurs when the trigeminal root is sectioned via the temporal fossa, provided the root is totally divided. In two instances where only the lower half of the nerve was sectioned there has been a preservation of sensation over the face in all but several localized areas.

## PENETRATING WOUNDS OF THE ABDOMEN\*

By ARTHUR E. BILLINGS, M.D., AND ADOLPH WALKLING, M.D.  
OF PHILADELPHIA, PA.

FROM THE SURGICAL SERVICE OF THE PENNSYLVANIA HOSPITAL

WE HAVE reviewed the records of 220 cases of penetrating wounds of the abdomen admitted to the Pennsylvania Hospital during the years 1909 to 1930 inclusive, and for the privilege of reporting them we are much indebted to Drs. John H. Gibbon and Charles F. Mitchell, surgeons-in-chief to the hospital, and to the former chiefs upon whose services they were admitted. We have not included in this series any cases with penetrating wounds other than those resulting from stab and gunshot injuries. We are considering the two groups separately because the stab wounds, as a group, are less serious than the gunshot cases, for the reason that, in the latter, there is more hæmorrhage and more extensive visceral injury.

In this series, about the usual ratio of danger of the gunshot over the stab injuries was maintained, that is, a little more than 2 to 1. The operative mortality in civil life seems to have been established around the 50 per cent. level for gunshot wounds and about 25 per cent. for the stab injuries, with a considerably higher total rate for both groups. In the gunshot cases, Wallace, reporting on 1200 cases from the British Expeditionary Force, showed an operative mortality of 53.9 per cent., and a total mortality including non-operative cases of 60.2 per cent. Lockwood, Kennedy, *et al.*, in military service, reported on 500 cases with an operative mortality of 51.97 per cent. In 1902, Fener reported on 152 cases of gunshot wounds from the Charity Hospital, New Orleans, 96 of which suffered visceral injury with 71 deaths (74 per cent.). Bivings, in 66 cases operated upon, reported a mortality of 60.6 per cent. McKeithen's mortality on 56 gunshot cases was 44.6 per cent., and on 13 stab cases 30.7 per cent.

The experience of the Charity Hospital in New Orleans in these injuries seems to have been greater than that of any other institution, and they have appointed, under the direction of Doctor Matas, a special committee for the study of these cases. Miller's report on a personal experience in 46 cases operated upon there with 23 recoveries, and a paper by Loria dealing with "visceral injuries in gunshot wounds of the abdomen" are the latest communications from this institution. Mason, in his last report, analyzed 127 cases, stressing the influence of hæmorrhage on mortality, and has divided his series into a large and small hæmorrhage group regardless of visceral injury, showing a mortality of 87.2 per cent. in the large hæmorrhage series, and 36.1 per cent. in the small hæmorrhage series. He urges strongly the

\*Read before the Philadelphia Academy of Surgery, May 4, 1931.

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more routine use of blood transfusion in these cases. Condict has reported a series of 20 cases from the Gouverneur Hospital, with 11 recoveries.

Winslow, in a report of 31 cases of gunshot and stab wounds of the abdomen treated at the University Hospital, Baltimore, resulting in 16 recoveries and 15 deaths, says that in two cases which died, perforations of the intestine were overlooked at operation. We feel that overlooked injury at the time of operation is one of the most important causes of the present high death rate in perforating wounds of the abdomen. Since studying our own series we are more strongly convinced than ever of this fact, and we may add that with this conviction there has also come a good deal of chagrin, and a lesson which we know will be helpful personally and we hope may be of some assistance to others in the treatment of these injuries. The operations in our series were performed by the attending and assistant attending members of the staff, and the former chief resident physicians of the hospital during this period.

TABLE I

Stab Cases				Gunshot Cases			
Recoveries		Deaths		Recoveries		Deaths	
		Non-				Non-	
		Operative	operative			Operative	operative
Age average...	31.7	40.5	33	26.1	32.9	31	
Colored.....	35	7	2	20	24	6	
White.....	27	10	2	41	31	14	
Male.....	56	15	4	53	47	18	
Female.....	6	2	0	8	8	2	

## *Stab Wounds*

Total stab-wound cases.....	84	{ recoveries..... 63
		{ deaths..... 21
Cases operated upon.....	77	{ recoveries..... 60
		{ deaths..... 17
Cases not operated upon.....	7	{ recoveries..... 3
		{ deaths..... 4

The total mortality of the stab-wound cases is 25 per cent.; the operative mortality is 22 per cent. A brief analysis of the cases recovering after operation revealed that in 19 instances there was penetration without visceral injury.

## GROUP I

### *Stab-wound Injuries—Operation—Recovery*

CASE I.—Colored man, thirty-two years old. Operation, hours after injury.—? Location of wound.—Upper right abdomen. Operative findings.—Wound of liver, diaphragm and pleura. Operation.—Laparotomy, liver pack, secondary rib resection, drainage. Complications.—Sub-diaphragmatic abscess. Days in hospital.—Sixty-five.

CASE II.—Colored man, thirty-one years old. Operation, hours after injury.—Three and one-half. Location of wound.—Lower right abdomen, anterior. Operative

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findings.—Intestine protruding; slight hæmorrhage. Operation.—Exploratory laparotomy; irrigation N. S. S.; drainage. Days in hospital.—Twenty-one.

CASE III.—White man, twenty-three years old. Operation, hours after injury.—? Location of wound.—Lower right abdomen, anterior. Operative findings.—Penetrating wound; slight hæmorrhage. Operation.—Exploratory laparotomy; no drainage. Days in hospital.—Eighteen.

CASE IV.—White man, forty-seven years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper left abdomen, anterior. Operative findings.—Laceration of mesentery, slight hæmorrhage. Operation.—Laparotomy, ligation; no drainage; irrigation N. S. S. Days in hospital.—Twenty.

CASE V.—White man, sixteen years old. Operation, hours after injury.—? Location of wound.—Lower left abdomen, anterior. Operative findings.—Four perforations ileum; laceration of mesentery; severe hæmorrhage. Operation.—Enterorrhaphy; irrigation N. S. S.; drainage. Days in hospital.—Thirty-two.

CASE VI.—White man, thirty-one years old. Operation, hours after injury.—One and one-quarter. Location of wound.—Upper left abdomen, from back. Operative findings.—Wound of spleen; diaphragm; pleura; slight hæmorrhage. Operation.—Laparotomy; drainage. Complications.—Pulmonary collapse. Days in hospital.—Twelve.

CASE VII.—Colored man, fifty years old. Operation, hours after injury.—Two. Location of wound.—Upper left abdomen, anterior. Operative findings.—Two perforations stomach; slight hæmorrhage. Operation.—Gastrorrhaphy; no drainage. Complications.—Local peritonitis. Days in hospital.—Thirty.

CASE VIII.—Colored man, thirty-six years old. Operation, hours after injury.—Three. Location of wound.—Upper mid-abdomen. Operative findings.—Wound of stomach; evisceration of stomach and omentum; moderate hæmorrhage. Operation.—Gastrorrhaphy. Days in hospital.—Thirteen.

CASE IX.—White man, twenty years old. Operation, hours after injury.—Four and one-half. Location of wound.—Upper left abdomen. Operative findings.—One perforation of small intestine; laceration mesentery. Operation.—Enterorrhaphy suture; no drainage. Days in hospital.—Thirteen.

CASE X.—White man, twenty-two years old. Operation, hours after injury.—Three. Location of wound.—Upper left abdomen. Operative findings.—Wound of stomach; slight hæmorrhage. Operation.—Gastrorrhaphy; no drainage. Days in hospital.—Thirty.

CASE XI.—White woman, thirty-eight years old. Operation, hours after injury.—? Location of wound.—Left lower abdomen. Operative findings.—Penetrating wound; severe hæmorrhage; external wound. Operation.—Exploratory laparotomy; no drainage. Days in hospital.—Eighteen.

CASE XII.—White man, twenty-one years old. Operation, hours after injury.—? Location of wound.—Upper left abdomen; anterior; multiple. Operative findings.—Wound of stomach; diaphragm; pleura. Operation.—Gastrorrhaphy; suture diaphragm; drainage. Days in hospital.—Twenty.

CASE XIII.—White man, twenty-two years old. Operation, hours after injury.—? Location of wound.—Lower left abdomen. Operative findings.—Penetrating wound. Operation.—Exploratory laparotomy; no drainage. Complications.—Partial obstruction fifth day. Days in hospital.—Seventeen.

CASE XIV.—White man, twenty-two years old. Operation, hours after injury.—Eighteen. Location of wound.—Upper left abdomen; anterior. Operative findings.—Wound of diaphragm. Operation.—Exploratory laparotomy; suture diaphragm; no drainage. Days in hospital.—Fifteen.

CASE XV.—White man, twenty-five years old. Operation, hours after injury.—One. Location of wound.—Upper left abdomen, lateral. Operative findings.—Laceration of



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mesentery; moderate hæmorrhage. Operation.—Exploratory laparotomy; suture mesentery; drainage. Days in hospital.—Eleven.

CASE XVI.—White man, forty-seven years old. Operation, hours after injury.—Two. Location of wound.—Lower abdomen. Operative findings.—Laceration of mesentery; evisceration of small intestine and omentum; moderate hæmorrhage. Operation.—Repair mesentery; no drainage. Complications.—Pneumonia. Days in hospital.—Twenty-five.

CASE XVII.—White man, thirty-one years old. Operation, hours after injury.—Two. Location of wound.—Lower right abdomen; anterior. Operative findings.—Omentum protruding; no visceral injury. Operation.—Exploratory laparotomy; drainage. Complications.—Local peritonitis. Days in hospital.—Thirteen.

CASE XVIII.—White man, twenty-three years old. Operation, hours after injury.—? Location of wound.—Upper left abdomen; anterior. Operative findings.—Small puncture liver; slight hæmorrhage. Operation.—Exploratory laparotomy; suture liver; drainage. Days in hospital.—Twenty-three.

CASE XIX.—Colored man, fifty years old. Operation, hours after injury.—One and three-quarters. Location of wound.—Lower left abdomen; anterior. Operative findings.—Penetrating wound; small intestine protruding. Operation.—Exploratory laparotomy; drainage. Days in hospital.—Twenty.

CASE XX.—White man, twenty-two years old. Operation, hours after injury.—Three. Location of wound.—Upper right abdomen; anterior. Operative findings.—Four perforations large intestine; severe hæmorrhage. Operation.—Enterorrhaphy; irrigation N. S. S.; drainage. Days in hospital.—Twenty-eight.

CASE XXI.—White man, twenty years old. Operation, hours after injury.—One. Location of wound.—Lower left abdomen; lateral. Operative findings.—Penetrating wound; omentum protruding. Operation.—Exploratory laparotomy; drainage. Days in hospital.—Thirteen.

CASE XXII.—White man, twenty-six years old. Operation, hours after injury.—? Location of wound.—Abdomen. Operative findings.—Penetrating wound; slight hæmorrhage. Operation.—Exploratory laparotomy; drainage. Days in hospital.—Fourteen.

CASE XXIII.—Colored man, twenty-seven years old. Operation, hours after injury.—One. Location of wound.—Upper left abdomen; anterior. Operative findings.—Wound of stomach; laceration of omentum; moderate hæmorrhage. Operation.—Gastrorrhaphy; repair omentum; drainage. Complications.—Pulmonary collapse right lower lobe. Days in hospital.—Nineteen.

CASE XXIV.—Colored man, twenty-four years old. Operation, hours after injury.—One and one-half. Location of wound.—Lower left abdomen; anterior. Operative findings.—Penetrating wound. Operation.—Exploratory laparotomy; no drainage. Days in hospital.—Nine.

CASE XXV.—White man, thirty-five years old. Operation, hours after injury.—? Location of wound.—Upper left abdomen; chest. Operative findings.—Two perforations jejunum; multiple wounds mesentery; puncture left pleura; severe hæmorrhage. Operation.—Resection of jejunum with end-to-end anastomosis; drainage. Days in hospital.—Thirty-two.

CASE XXVI.—Colored man, twenty-four years old. Operation, hours after injury.—Four. Location of wound.—Upper left abdomen; anterior. Operative findings.—Penetrating wound; slight hæmorrhage. Operation.—Exploratory laparotomy; no drainage. Days in hospital.—Twelve.

CASE XXVII.—White man, twenty-eight years old. Operation, hours after injury.—One. Location of wound.—Upper and lower right abdomen. Operative findings.—Wound of bladder; slight hæmorrhage. Operation.—Suture bladder; drainage. Days in hospital.—Sixteen.

CASE XXVIII.—White man, twenty-five years old. Operation, hours after injury.—Five and one-half. Location of wound.—Lower right abdomen; anterior. Operative

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findings.—Penetrating wound; laceration of omentum; omentum protruding; moderate hæmorrhage. Operation.—Exploratory laparotomy; suture; ligation; no drainage. Days in hospital.—Fourteen.

CASE XXIX.—Colored man, forty-two years old. Operation, hours after injury.—Two and one-half. Location of wound.—Lower left abdomen; anterior. Operative findings.—One perforation small intestine; moderate hæmorrhage. Operation.—Enterorrhaphy; suture; drainage. Days in hospital.—Seventeen.

CASE XXX.—White man, twenty-six years old. Operation, hours after injury.—Two. Location of wound.—Upper right abdomen; anterior. Operative findings.—Penetrating wound. Operation.—Exploratory laparotomy; no drainage. Complications.—Infection of wound. Days in hospital.—Twenty.

CASE XXXI.—Colored man, forty-nine years old. Operation, hours after injury.—Two and one-half. Location of wound.—Anterior abdomen. Operative findings.—Penetrating wound; severe hæmorrhage from omentum. Operation.—Exploratory laparotomy; ligation; no drainage. Days in hospital.—Nineteen.

CASE XXXII.—Colored man, thirty-six years old. Operation, hours after injury.—One. Location of wound.—Upper left abdomen; posterior lateral. Operative findings.—Small intestine protruding through penetrating wound. Operation.—Exploratory laparotomy; no drainage. Days in hospital.—Nineteen.

CASE XXXIII.—White man, thirty-five years old. Operation, hours after injury.—Three-quarters. Location of wound.—Upper left abdomen; anterior. Operative findings.—Laceration of mesentery of small intestine. Operation.—Exploratory laparotomy; suture; no drainage. Days in hospital.—Fourteen.

CASE XXXIV.—White man, thirty-eight years old. Operation, hours after injury.—Two. Location of wound.—Upper left abdomen; anterior. Operative findings.—Severance of hypogastric vein; wound of mesentery; descending colon. Operation.—Exploratory laparotomy; ligation. Days in hospital.—Eighteen.

CASE XXXV.—White man, thirty-nine years old. Operation, hours after injury.—One. Location of wound.—Upper left abdomen; anterior. Operative findings.—Perforation of jejunum; laceration of mesentery; hæmorrhage. Operation.—Enterorrhaphy; suture; no drainage. Days in hospital.—Eighteen.

CASE XXXVI.—Colored man, twenty-six years old. Operation, hours after injury.—Two. Location of wound.—Upper left abdomen; anterior. Operative findings.—Penetrating wound of liver; moderate hæmorrhage. Operation.—Laparotomy; suture of liver; no drainage. Days in hospital.—Fourteen.

CASE XXXVII.—Colored man, ? years old. Operation, hours after injury.—One. Location of wound.—Lower right abdomen; anterior. Operative findings.—Penetrating wound. Operation.—Exploratory laparotomy; no drainage. Days in hospital.—Sixteen.

CASE XXXVIII.—Colored woman, fifty years old. Operation, hours after injury.—Three and one-half. Location of wound.—Left lateral abdomen (flank). Operative findings.—Penetrating wound; laceration mesentery; descending colon. Operation.—Exploratory laparotomy; ligation; drainage. Days in hospital.—Thirty.

CASE XXXIX.—Colored man, eighteen years old. Operation, hours after injury.—One. Location of wound.—Lower right abdomen; anterior. Operative findings.—Omentum protruding. Operation.—Omentum excised; no drainage. Days in hospital.—Thirteen.

CASE XL.—Colored man, thirty-five years old. Operation, hours after injury.—Fourteen. Location of wound.—Lower left abdomen; anterior. Operative findings.—Penetrating wound; slight hæmorrhage. Operation.—Exploratory laparotomy; drainage. Complications.—Local peritonitis. Days in hospital.—Fourteen.

CASE XLI.—Colored man, thirty-five years old. Operation, hours after injury.—One. Location of wound.—Upper left abdomen; anterior. Operative findings.—Pene-

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trating wound; evisceration jejunum; slight hæmorrhage. Operation.—Exploratory laparotomy; ligation; no drainage. Days in hospital.—Seventeen.

CASE XLII.—White man, twenty-eight years old. Operation, hours after injury.—One. Location of wound.—Upper left abdomen; lateral (flank). Operative findings.—Two perforations small intestine; two of large intestine; laceration of mesentery; severe hæmorrhage. Operation.—Enterorrhaphy, with drainage. Days in hospital.—Thirty.

CASE XLIII.—Colored man, twenty-five years old. Operation, hours after injury.—Nine and one-half. Location of wound.—Upper left abdomen; anterior. Operative findings.—One perforation small intestine; laceration of mesentery; severe hæmorrhage. Operation.—Enterorrhaphy; suture; ligation; no drainage. Complications.—General peritonitis. Days in hospital.—Twenty-three.

CASE XLIV.—White man, forty years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper and lower left abdomen; anterior. Operative findings.—Evisceration of omentum and small intestine. Operation.—Exploratory laparotomy; no drainage. Days in hospital.—Sixteen.

CASE XLV.—White man, thirty-two years old. Operation, hours after injury.—Seven. Location of wound.—Lower left abdomen; anterior. Operative findings.—Laceration peritoneal; coat of sigmoid; slight hæmorrhage. Operation.—Exploratory laparotomy; suture; no drainage. Days in hospital.—Seventeen.

CASE XLVI.—Colored man, thirty-four years old. Operation, hours after injury.—Two. Location of wound.—Lower left abdomen. Operative findings.—Penetrating wound; omentum protruding. Operation.—Exploratory laparotomy; with drainage. Complications.—Wound infection. Days in hospital.—Thirty-four.

CASE XLVII.—Colored man, thirty-five years old. Operation, hours after injury.—One and one-quarter. Location of wound.—Lower left abdomen. Operative findings.—One perforation small intestine; slight hæmorrhage; evisceration small intestine. Operation.—Enterorrhaphy; suture; with drainage. Days in hospital.—Eighteen.

CASE XLVIII.—Colored woman, twenty-three years old. Operation, hours after injury.—Eight. Location of wound.—Upper right abdomen; anterior. Operative findings.—Laceration of gastrocolic omentum; severe hæmorrhage. Operation.—Exploratory laparotomy; drainage. Complications.—Wound infection. Days in hospital.—Thirty-three.

CASE XLIX.—Colored man, thirty-one years old. Operation, hours after injury.—One. Location of wound.—Upper left abdomen; anterior. Operative findings.—Laceration mesentery; transverse colon; moderate hæmorrhage. Operation.—Exploratory laparotomy; ligation; drainage. Complications.—Wound infection. Days in hospital.—Nineteen.

CASE L.—Colored man, twenty-five years old. Operation, hours after injury.—Two. Location of wound.—Lower right abdomen; anterior. Operative findings.—One perforation small intestine; omentum protruding; slight hæmorrhage. Operation.—Enterorrhaphy; suture; drainage. Complications.—Local peritonitis. Days in hospital.—Twenty-seven.

CASE LI.—Colored woman, twenty-two years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver; severe hæmorrhage. Operation.—Exploratory laparotomy; pack; drainage. Days in hospital.—Fifteen.

CASE LII.—Colored man, ? years old. Operation, hours after injury.—Five. Location of wound.—Upper left abdomen. Operative findings.—Laceration of mesentery; moderate hæmorrhage. Operation.—Exploratory laparotomy; ligation; drainage. Complications.—Left pleurisy. Days in hospital.—Seventeen.

CASE LIII.—White man, thirty-two years old. Operation, hours after injury.—Two and one-half. Location of wound.—Upper left abdomen; anterior. Operative findings.—Penetrating wound; round ligament of liver severed. Operation.—Exploratory laparotomy; no drainage. Days in hospital.—Fifteen.

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CASE LIV.—Colored man, thirty-four years old. Operation, hours after injury.—Two. Location of wound.—Upper left abdomen; anterior. Operative findings.—Laceration of gall-bladder; omentum protruding; slight hæmorrhage. Operation.—Exploratory laparotomy; suture ligation with drainage. Days in hospital.—Eighteen.

CASE LV.—Colored man, thirty-nine years old. Operation, hours after injury.—Five. Location of wound.—Upper left abdomen; lateral. Operative findings.—Penetrating wound; severe hæmorrhage; laceration gastrocolic omentum; omentum protruding. Operation.—Exploratory laparotomy; ligation with drainage; reinfusion 500 cubic centimetres of blood. Complications.—Wound infection. Days in hospital.—Twenty-three.

CASE LVI.—Colored man, twenty-two years old. Operation, hours after injury.—One-half. Location of wound.—Lower left abdomen; anterior. Operative findings.—One perforation small intestine; slight hæmorrhage; omentum protruding. Operation.—Enterorrhaphy; no drainage. Days in hospital.—Eleven.

CASE LVII.—Colored female, twenty-eight years old. Operation, hours after injury.—Ten. Location of wound.—Upper left abdomen, from back. Operative findings.—One perforation large intestine; descending colon. Operation.—Enterorrhaphy, with drainage. Complications.—Wound infection. Days in hospital.—Twenty-three.

CASE LVIII.—Colored man, twenty-nine years old. Operation, hours after injury.—Two. Location of wound.—Upper left abdomen; posterior. Operative findings.—Laceration of spleen (slight) and diaphragm; slight hæmorrhage; omentum protruding. Operation.—Exploratory laparotomy; suture with drainage. Complications.—Wound rupture ninth day; resutured. Days in hospital.—Thirty-one.

CASE LIX.—Colored man, thirty-eight years old. Operation, hours after injury.—Four. Location of wound.—Upper left abdomen; anterior. Operative findings.—Wound of liver; pancreas (slight); severe hæmorrhage. Operation.—Exploratory laparotomy; packing with drainage. Days in hospital.—Seventeen.

CASE LX.—Colored man, twenty-five years old. Operation, hours after injury.—Twelve. Location of wound.—Upper left abdomen; anterior. Operative findings.—One perforation of anterior wall of stomach. Operation.—Gastrorrhaphy; suture with drainage. Complications.—Wound infection. Days in hospital.—Twenty-three.

### *Stab-wound Injuries—No Operation—Recovery*

CASE I.—White man, thirty-five years old. Multiple stab wounds, penetrating, but probably no perforations. Refused operation. Left hospital in two days with signs of peritonitis still present. Readmitted to hospital three times during the next month without abdominal symptoms, but infection still present in shoulder wounds.

CASE II.—Colored man, thirty-six years old. Single stab wound, penetrating but probably no visceral injury. Refused operation. Apparently had local peritonitis which subsided. Left hospital in five days, earlier than advised; but in good condition.

CASE III.—Colored man, thirty-two years old. Multiple stab wounds. Penetrating wound right thoracic cavity, surgical emphysema (no effusion of consequence); penetrating wound upper abdomen without visceral injury; no peritonitis; no infection of wounds; no complications. Left the hospital in eleven days.

### *Stab-wound Injuries—Operation—Death*

CASE I.—Colored man, twenty-four years old. Operation, hours after injury.—One and three-quarters. Location of wound injury.—Lower right abdomen; anterior. Operative findings.—Two perforations small intestine; two of large intestine; severe hæmorrhage. Operation.—Enterorrhaphy; irrigation N. S. S.; drainage. Time and autopsy cause of death.—Fourteen hours; hæmorrhage; shock; early peritonitis.

CASE II.—Colored woman, fifty-seven years old. Operation, hours after injury.—Two. Location of wound injury.—Upper left abdomen. Operative findings.—Wound



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on under surface of liver; severe hæmorrhage. Operation.—Exploratory laparotomy; packing. Time and autopsy cause of death.—On table; hæmorrhage; shock.

CASE III.—White man, thirty-six years old. Operation, hours after injury.—Twenty-one. Location of wound injury.—Upper left abdomen; anterior. Operative findings.—One perforation of stomach; wound of diaphragm; moderate hæmorrhage. Operation.—Gastrorrhaphy; suture diaphragm. Complications.—Delirium tremens. Time and autopsy cause of death.—Four days; peritonitis; pneumonia; pleurisy; pericarditis.

CASE IV.—Colored man, twenty-one years old. Operation, hours after injury.—Three. Location of wound injury.—Lower left abdomen. Operative findings.—Wound of mesentery; severe hæmorrhage. Operation.—Repair mesentery; suture pack; drainage. Complications.—General peritonitis; lobar-broncho pneumonia. Time and autopsy cause of death.—Four days; general peritonitis; lobar and broncho pneumonia.

CASE V.—White man, thirty-nine years old. Operation, hours after injury.—? Location of wound injury.—Left mid-abdomen. Operative findings.—Six perforations descending colon; severe hæmorrhage. Operation.—Enterorrhaphy; drainage. Complications.—Wound infection. Time and autopsy cause of death.—Four days; peritonitis; pneumonia; leakage from site of repair.

CASE VI.—Colored man, twenty-nine years old. Operation, hours after injury.—Two and one-half. Location of wound injury.—Left lower abdomen; anterior; left chest; anterior. Operative findings.—No evidence of visceral injury or bleeding found first operation; vomiting seventh day; tenth day second operation; obstruction; intestinal leakage at site of obstruction; four days later third operation; intestinal obstruction; leakage feces from wound; condition improved very much for six days; then gradually got worse; died fourteen days after third operation. Operation.—Exploratory laparotomy; no drainage; second operation, resection; end-to-end anastomosis; drainage; third operation, drainage. Complications.—Abdominal infection; obstruction; general peritonitis; faecal fistula. Time and autopsy cause of death.—Twenty-eight days; general peritonitis and intestinal obstruction; left subphrenic abscess.

CASE VII.—White man, forty-seven years old. Operation, hours after injury.—One and three-quarters. Location of wound injury.—Upper right abdomen; anterior. Operative findings.—Wound of liver; moderate hæmorrhage. Operation.—Exploratory laparotomy; suture with drainage. Complications.—Meningitis. Time and autopsy cause of death.—Twenty-three days; peritonitis; subphrenic abscess; septic nephritis.

CASE VIII.—White man, seventy years old. Operation, hours after injury.—One. Location of wound injury.—Lower right abdomen; anterior. Operative findings.—Suicide; excision section small intestine; completely severed colon; severe hæmorrhage. Operation.—Fixation of severed ends of intestines to abdominal wall. Time and autopsy.—Three and one-half days; shock and peritonitis; no autopsy.

CASE IX.—White man, fifty years old. Operation, hours after injury.—Two. Location of wound injury.—Left abdomen; upper lateral. Operative findings.—Wound of spleen and stomach; profuse hæmorrhage; diaphragm injured. Operation.—Splenic pedicle clamped; packing. Time and autopsy cause of death.—On table; severe hæmorrhage before operation was concluded.

CASE X.—White man, twenty-nine years old. Operation, hours after injury.—Eight (refused early operation). Location of wound injury.—Upper left abdomen; anterior. Operative findings.—Injury to posterior wall of stomach; diaphragm; pleura; moderate hæmorrhage. Operation.—Gastrorrhaphy; suture with drainage. Complications.—Collapse of left lung; early peritonitis; pleurisy. Time and autopsy cause of death.—Fifteen hours; hæmorrhage; shock.

CASE XI.—Colored man, ? years old. Operation, hours after injury.—One. Location of wound injury.—Upper right abdomen; anterior. Operative findings.—Wound through edge of liver; severe hæmorrhage; laceration gastrohepatic omentum. Operation.—Exploratory laparotomy; three large packs with drainage. Time and autopsy



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cause of death.—Four hours; hæmorrhage; penetration right pleura; wound superior vena cava overlooked at operation.

CASE XII.—Colored man, thirty-five years old. Operation, hours after injury.—One and one-half. Location of wound injury.—Upper left abdomen; anterior. Operative findings.—Wound of stomach; severe hæmorrhage; second operation for rupture of wound with evisceration of intestines. Operation.—First operation, gastrorrhaphy; no drainage; second operation second day, wound repair; drainage. Complications.—Ruptured wound; general peritonitis. Time and autopsy cause of death.—Four days; general peritonitis.

CASE XIII.—White man, twenty-six years old. Operation, hours after injury.—One to two. Location of wound injury.—Left abdomen; anterior. Operative findings.—One perforation small intestine; injury to mesenteric border of ileum; severe hæmorrhage. Operation.—Enterorrhaphy; no drainage; second day after operation drained for peritonitis. Complications.—General peritonitis. Time and autopsy cause of death.—Two days; general peritonitis; fulminating.

CASE XIV.—White man, forty-four years old. Operation, hours after injury.—One and one-half. Location of wound injury.—Right abdomen; multiple of chest and body (17 wounds). Operative findings.—One perforation of stomach; transverse colon; laceration of omentum; moderate hæmorrhage; wound of left lung. Operation.—Gastrorrhaphy; enterorrhaphy; repair omentum; drainage. Complications.—Delirium tremens. Time and autopsy cause of death.—Seven days; peritonitis; wounds of liver and left kidney overlooked.

CASE XV.—Colored man, sixty years old. Operation, hours after injury.—One. Location of wound injury.—Upper and lower right abdomen; anterior (multiple). Operative findings.—Laceration of liver; penetrating wounds; moderate hæmorrhage. Operation.—Laparotomy; packing liver wound (too tight). Complications.—Pulmonary œdema; biliary fistula. Time and autopsy cause of death.—Seven days; pneumonia; infection of liver wound; subphrenic abscess.

CASE XVI.—Colored woman, twenty-five years old. Operation, hours after injury.—Four and one-half. Location of wound injury.—Upper left abdomen; anterior. Operative findings.—Six perforations jejunum; one of transverse colon; moderate hæmorrhage. Operation.—Enterorrhaphy; ligation; suture; drainage. Complications.—Local peritonitis; pulmonary œdema. Time and autopsy cause of death.—Four days; hæmorrhage; shock; advanced pulmonary tuberculosis contributing cause.

CASE XVII.—White man, fifty-three years old. Operation, hours after injury.—Eighteen. Location of wound injury.—Lower left abdomen; anterior; multiple. Operative findings.—Multiple perforations small intestine and mesentery; one of mesosigmoid; moderate hæmorrhage. Operation.—Resection of fifteen inches ileum and lateral anastomosis; drainage. Time and autopsy cause of death.—Four days; septic peritonitis.

### *Stab-wound Injuries—No operation—Death*

CASE I.—White man, forty years old. Multiple stab wounds of heart and abdomen; penetrating. Died two minutes after admission. No autopsy.

CASE II.—White man, forty-two years old. Single stab wound left upper abdomen. Had generalized œdema with cardiac decompensation. Suicide. Died in twenty hours. No autopsy.

CASE III.—Colored man, ? years old. Single stab wound left upper abdomen. Died immediately after admission. Autopsy showed clot in pericardium causing compression of heart; right side of right ventricle penetrated.

CASE IV.—Colored man, twenty-three years old. Single stab wound epigastrium. Signs of severe hæmorrhage; omentum protruding. Died in twenty minutes. No autopsy.

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The mesentery was injured in 17 cases (no associated injuries in 7)  
 The omentum was injured in 6 cases (no associated injuries in 2)  
 The stomach was injured in 6 cases (multiple—1)  
 The small intestine was injured in 11 cases (multiple—3)  
 The large intestine was injured in 3 cases (multiple—2)  
 The urinary bladder was injured in 1 case  
 The liver was injured in 3 cases  
 The spleen was injured in 1 case (small wound)  
 The pancreas was injured in 1 case (small wound)

Evisceration was noted in 17 instances { intestine..... 8  
 stomach..... 1  
 omentum..... 8

In 7 cases the pleural cavity was penetrated { unilateral..... 6  
 bilateral..... 1

The diaphragm was perforated in 5 cases.

Hæmorrhage was severe in 7 cases, moderate in 11, and slight in 16. In 26 there was no note as to hæmorrhage. Shock as a rule was not marked except when associated with considerable hæmorrhage. It was surprisingly slight in most of the evisceration cases. In several instances the patients had walked into the receiving ward with a part of their intestines resting in their clothes with but little evidence of shock. The operative procedure in this group was very simple.

A resection with end-to-end anastomosis was done in one case for multiple injuries to the jejunum and its mesentery. In 20 cases the wound was closed without drainage, including 14 without visceral injury, 3 stomach perforations, 2 small intestine perforations, and one liver wound. The complications included—wound infection, 7; rupture of wound and evisceration (ninth day), 1; partial obstruction, 1; pneumonia, 2; pulmonary collapse, 2; pleurisy, 1; subphrenic abscess, 1; and phlebitis, 1.

Three cases recovered without operation who suffered penetrating wounds. Two of these patients refused to have operations performed. The other one was admitted many hours after being stabbed without symptoms of visceral injury, and was treated conservatively. We do not believe that any of them suffered visceral damage.

Seventeen of the 77 cases operated upon died. Autopsies were performed on 15 cases (88 per cent.). There are a few outstanding features in this group. In 9 cases hæmorrhage was severe, and in 7 it was moderate in amount. Four deaths occurred within fifteen hours, and can be attributed directly to hæmorrhage and shock. Thirteen died within four days, and all severe hæmorrhage cases died within four days. In 2 cases resection of small intestine was done (one lateral and one end-to-end anastomosis). In four cases the abdomen was closed without drainage. At autopsy peritonitis was found in 11 cases, pneumonia in 3, and subphrenic abscess in three. Wounds of the liver and left kidney were overlooked at operation in a case suffering multiple penetrating wounds of chest and abdomen with perforations of stomach and colon. The cause of death was peritonitis on the

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seventh day. In one case leakage occurred after repair of six perforations of the colon. Death resulted on the fourth day from peritonitis.

<i>Gunshot Wounds</i>		
Total gunshot-wound cases.....	136	<div style="display: inline-block; vertical-align: middle;"> <div style="display: inline-block; vertical-align: middle;">{</div> <div style="display: inline-block; vertical-align: middle;"> recoveries..... 61  deaths..... 75 </div> </div>
Cases operated upon .....	114	<div style="display: inline-block; vertical-align: middle;"> <div style="display: inline-block; vertical-align: middle;">{</div> <div style="display: inline-block; vertical-align: middle;"> recoveries..... 59  deaths..... 55 </div> </div>
Cases not operated upon.....	22	<div style="display: inline-block; vertical-align: middle;"> <div style="display: inline-block; vertical-align: middle;">{</div> <div style="display: inline-block; vertical-align: middle;"> recoveries..... 2  deaths..... 20 </div> </div>

A total mortality of 55.14 per cent. is shown in this group and an operative mortality of 48.2 per cent. In the group of operative recoveries of which there were 59, hæmorrhage was severe in 27, moderate in 12, slight in 12, and no note as to hæmorrhage in 8 cases. In 21 cases visceral injuries were single, and in 32 they were multiple.

### GROUP II

#### *Gunshot Wound Injuries—Operation—Recovery*

CASE I.—Colored man, forty-two years old. Operation, hours after injury.—Two. Location of wound.—Upper left abdomen; anterior. Operative findings.—Wound of liver; severe hæmorrhage. Operation.—Packing wound; drainage. Days in hospital.—Thirty-four.

CASE II.—Colored man, twenty-seven years old. Operation, hours after injury.—One and one-quarter. Location of wound.—Lower left abdomen; anterior. Operative findings.—Two perforations sigmoid; moderate hæmorrhage. Operation.—Enterorrhaphy; suture; drainage. Complications.—Wound infection. Days in hospital.—Eighteen.

CASE III.—Colored man, twenty-seven years old. Operation, hours after injury.—Three. Location of wound.—Lower left abdomen; anterior. Operative findings.—Wound of bladder; slight hæmorrhage. Operation.—Marsupialization with drainage. Days in hospital.—Fifty-nine.

CASE IV.—White man, seventy-three years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper left abdomen; anterior. Operative findings.—Perforation of stomach; severe hæmorrhage. Operation.—Gastrorrhaphy; suture; drainage. Days in hospital.—Fifty-nine.

CASE V.—White man, nineteen years old. Operation, hours after injury.—One and one-half. Location of wound.—Mid-abdomen. Operative findings.—Two perforations jejunum; severe hæmorrhage. Operation.—Enterorrhaphy; suture; packing. Complications.—Pneumonia effusion. Days in hospital.—Forty.

CASE VI.—White woman, sixteen years old. Operation, hours after injury.—? Location of wound.—Right upper abdomen. Operative findings.—Wound of liver; severe hæmorrhage. Operation.—Packing wound. Days in hospital.—Fourteen.

CASE VII.—Colored man, twenty-six years old. Operation, hours after injury.—Three and one-half. Location of wound.—Lower left abdomen; posterior. Operative findings.—Wound right ureter. Operation.—Drainage. Complications.—Urinary fistula; posterior; healed spontaneously. Days in hospital.—Forty-four.

CASE VIII.—Colored woman, twenty-five years old. Operation, hours after injury.—Two. Location of wound.—Lower left abdomen; anterior. Operative findings.—Wound of liver; severe hæmorrhage. Operation.—Packing wound; drainage. Complications.—Liver abscess? drainage; fever five weeks. Days in hospital.—Seventy.

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CASE IX.—White man, twenty-one years old. Operation, hours after injury.—Two. Location of wound.—Upper left abdomen; anterior. Operative findings.—Wound of liver; moderate hæmorrhage. Operation.—Packing wound. Complications.—Pleurisy; pneumonia. Days in hospital.—Nineteen.

CASE X.—White woman, twenty-three years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of pancreas; one perforation of small intestine and one of stomach; moderate hæmorrhage. Operation.—Gastrorrhaphy; enterorrhaphy; suture; drainage. Complications.—Duodenal fistula; local peritonitis; fistula healed spontaneously. Days in hospital.—Ninety-two.

CASE XI.—White man, twenty-seven years old. Operation, hours after injury.—One. Location of wound.—Upper right abdomen; anterior. Operative findings.—Two perforations stomach; six perforations small intestine; one of transverse colon and one of rectum; moderate hæmorrhage. Operation.—Gastrorrhaphy; enterorrhaphy; irrigation with N. S. S., drainage. Days in hospital.—Twenty-five.

CASE XII.—White man, twenty-five years old. Operation, hours after injury.—Five. Location of wound.—Upper left abdomen; anterior. Operative findings.—Wound of diaphragm; pleura. Operation.—Laparotomy; no drainage. Days in hospital.—Twelve.

CASE XIII.—White man, twenty-two years old. Operation, hours after injury.—One to one and one-half. Location of wound.—Upper left abdomen; posterior. Operative findings.—Wound of liver and stomach; moderate hæmorrhage. Operation.—Gastrorrhaphy; drainage. Days in hospital.—Thirty.

CASE XIV.—White man, thirty-three years old. Operation, hours after injury.—? Location of wound.—Upper left abdomen; posterior. Operative findings.—Penetrating wound. Operation.—Laparotomy; no drainage. Days in hospital.—Nineteen.

CASE XV.—White girl, twelve years old. Operation, hours after injury.—? Location of wound.—Lower abdomen. Operative findings.—Two perforations small intestine; slight hæmorrhage. Operation.—Enterorrhaphy; drainage. Days in hospital.—Fifteen.

CASE XVI.—White man, forty-three years old. Operation, hours after injury.—Twenty-seven. Location of wound.—Upper right abdomen; two wounds. Operative findings.—One perforation of cæcum; moderate hæmorrhage. Operation.—Enterorrhaphy; drainage. Days in hospital.—Twenty-three.

CASE XVII.—Colored man, twenty-eight years old. Operation, hours after injury.—? Location of wound.—Left upper abdomen. Operative findings.—Perforation of spleen; severe hæmorrhage. Operation.—Splenectomy; gauze pack; drainage; transfusion. Complications.—On twenty-fifth day onset of severe tertian malarial infection; plasmodia recovered; responded to quinine therapy. Days in hospital.—Forty-five.

CASE XVIII.—Colored man, forty years old. Operation, hours after injury.—Two to three. Location of wound.—Left upper abdomen. Operative findings.—No visceral injury; penetrating wound. Operation.—Exploratory laparotomy; no visceral injury. Complications.—Hemothorax; thorocotomy; drainage. Days in hospital.—Sixteen.

CASE XIX.—White boy, five years old. Operation, hours after injury.—? Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver; severe hæmorrhage. Operation.—Packing wound; drainage. Complications.—Biliary fistula; subphrenic abscess. Days in hospital.—Thirty-nine.

CASE XX.—Colored man, thirty-four years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper left abdomen; posterior. Operative findings.—Wound left kidney; severe hæmorrhage. Operation.—Nephrectomy; drainage. Complications.—Wound infection. Days in hospital.—Twenty-five.

CASE XXI.—White man, thirty-five years old. Operation, hours after injury.—One. Location of wound.—Upper right abdomen; lateral. Operative findings.—Wound of liver; anterior surface; severe hæmorrhage. Operation.—Packing of wound with vaseline gauze. Days in hospital.—One hundred and two.

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CASE XXII.—White man, twenty-three years old. Operation, hours after injury.—Two and three-quarters. Location of wound.—Lower abdomen; anterior. Operative findings.—Injury to veins in pelvis; severe hæmorrhage. Operation.—Packing in pelvis; drainage. Days in hospital.—Seventeen.

CASE XXIII.—White man, eighteen years old. Operation, hours after injury.—Twenty-six. Location of wound.—Upper right abdomen. Operative findings.—Two perforations small intestine; severe hæmorrhage; laceration mesentery. Operation.—Enterorrhaphy; drainage; suture. Complications.—Influenza. Days in hospital.—Thirty-one.

CASE XXIV.—Colored man, thirty years old. Operation, hours after injury.—Two. Location of wound.—Lower left abdomen; anterior. Operative findings.—Large hæmatoma in spermatic cord; moderate hæmorrhage. Operation.—Drainage. Days in hospital.—Fourteen.

CASE XXV.—White man, thirty-eight years old. Operation, hours after injury.—One. Location of wound. Lower abdomen. Operative findings.—Thirteen perforations small intestine; one of bladder; moderate hæmorrhage. Operation.—Enterorrhaphy; lateral anastomosis without resection; suture; drainage. Days in hospital.—Forty-four.

CASE XXVI.—Colored man, twenty-five years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper right abdomen; lateral. Operative findings.—Wound of liver and diaphragm; severe hæmorrhage. Operation.—Packing liver wound; drainage. Complications.—Wound infection. Days in hospital.—Twenty-three.

CASE XXVII.—White man, nineteen years old. Operation, hours after injury.—Two. Location of wound.—Lower abdomen from back. Operative findings.—Laceration gastro-colic omentum; injury lumbar plexus; severe hæmorrhage. Operation.—Suture; no drainage. Complications.—Paralysis left foot; wound infection; general peritonitis. Days in hospital.—Forty-three.

CASE XXVIII.—White man, thirty-four years old. Operation, hours after injury.—One and three-quarters. Location of wound.—Upper right abdomen from back. Operative findings.—Wound right lobe liver; right kidney; severe hæmorrhage. Operation.—Packing; drainage; suture. Days in hospital.—Twenty.

CASE XXIX.—White man, twenty-two years old. Operation, hours after injury.—Two. Location of wound.—Upper right, left abdomen; anterior. Operative findings.—Wound of liver and stomach; severe hæmorrhage. Operation.—Gastrorrhaphy; packing. Days in hospital.—Twenty-five.

CASE XXX.—Colored man, forty-one years old. Operation, hours after injury.—? Location of wound.—Lower left abdomen; anterior. Operative findings.—Four perforations small intestine; thrombosis of veins; mesentery. Operation.—Resection with lateral anastomosis; wound resutured sixth day; drainage. Complications.—General peritonitis. Days in hospital.—Thirty-four.

CASE XXXI.—White girl, twelve years old. Operation, hours after injury.—One. Location of wound.—Upper abdomen. Operative findings.—Wound of liver; spleen; stomach. Operation.—Suture; gauze pack; gastrorrhaphy; drainage. Days in hospital.—Twenty-six.

CASE XXXII.—White man, twenty-seven years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper abdomen; posterior; left side. Operative findings.—Upper edge of spleen nicked; slight hæmorrhage. Operation.—Packing vaseline gauze; drainage. Complications.—Pleurisy. Days in hospital.—Thirteen.

CASE XXXIII.—White man, thirty-two years old. Operation, hours after injury.—One. Location of wound.—Lower left abdomen; anterior. Operative findings.—Six perforations small intestine; one of sigmoid; several perforations omentum; severe hæmorrhage. Operation.—Enterorrhaphy; ligation; resection ileum; end-to-end anastomosis; no drainage. Complications.—General peritonitis; wound infections. Days in hospital.—Twenty-eight.

CASE XXXIV.—White man, eighteen years old. Operation, hours after injury.—?



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Location of wound.—Upper left abdomen; posterior. Operative findings.—One perforation of stomach; four of jejunum; slight hæmorrhage. Operation.—Gastrorrhaphy; enterorrhaphy; suture ligation; drainage. Complications.—Wound infection. Days in hospital.—Twenty-six.

CASE XXXV.—White man, forty years old. Operation, hours after injury.—? Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver; diaphragm; pleura; severe hæmorrhage. Operation.—Pack liver wound; drainage. Complications.—Subphrenic abscess; hemothorax. Days in hospital.—Sixty-six.

CASE XXXVI.—White man, thirty-eight years old. Operation, hours after injury.—One. Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver; diaphragm; pleura; moderate hæmorrhage. Operation.—Packing; drainage. Complications.—Pneumothorax. Days in hospital.—Eighteen.

CASE XXXVII.—Colored man, twenty-seven years old. Operation, hours after injury.—Three and one-half. Location of wound.—Upper left abdomen; lateral; flank. Operative findings.—Three perforations sigmoid; three of mesentery; moderate hæmorrhage. Operation.—Suture; enterorrhaphy; drainage. Complications.—Slight local peritonitis. Days in hospital.—Twenty-eight.

CASE XXXVIII.—White man, forty-one years old. Operation, hours after injury.—Five. Location of wound.—Lower left abdomen; anterior. Operative findings.—Nine perforations small intestine; severe hæmorrhage; laceration mesentery. Operation.—Enterorrhaphy; drainage; suture; ligation. Complications.—Wound infections. Days in hospital.—Twenty-four.

CASE XXXIX.—White man, forty-four years old. Operation, hours after injury.—One. Location of wound.—Upper right abdomen; anterior. Operative findings.—Penetrating wound of abdomen; slight hæmorrhage. Operation.—Exploratory laparotomy; no drainage. Complications.—Fracture right ileum. Days in hospital.—Seventeen.

CASE XL.—White man, twenty-six years old. Operation, hours after injury.—One. Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver; severe hæmorrhage. Operation.—Packing; drainage. Complications.—Wound infection; bronchopneumonia. Days in hospital.—Forty-five.

CASE XLI.—White boy, fifteen years old. Operation, hours after injury.—One. Location of wound.—Lower left abdomen; anterior. Operative findings.—Eight perforations of ileum. Operation.—Resection ileum; end-to-end anastomosis; no drainage. Complications.—Wound infection. Days in hospital.—Twenty-five.

CASE XLII.—White man, twenty-eight years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver; slight hæmorrhage. Operation.—Packing liver wound; drainage. Days in hospital.—Sixteen.

CASE XLIII.—White boy, fourteen years old. Operation, hours after injury.—? Location of wound.—Upper right abdomen; anterior. Operative findings.—Perforation of small intestine; laceration mesentery; ascending colon; retroperitoneal hematoma; slight hæmorrhage. Operation.—Enterorrhaphy; suture; drainage. Days in hospital.—Eighteen.

CASE XLIV.—Colored man, forty-one years old. Operation, hours after injury.—One. Location of wound.—Upper right abdomen; lateral. Operative findings.—Wound of liver; slight hæmorrhage. Operation.—Packing liver wound; drainage. Complications.—Fracture eleventh and twelfth ribs. Days in hospital.—Twenty-two.

CASE XLV.—Colored man, twenty-five years old. Operation, hours after injury.—Thirty-six. Location of wound.—Upper right buttock. Operative findings.—Wound of bladder. Operation.—Exploratory laparotomy; drainage; second operation thirty days later; bullet removed from bladder through suprapubic wound after localization by cystoscope. Days in hospital.—Forty-three.

CASE XLVI.—Colored man, twenty-four years old. Operation, hours after injury.—Two. Location of wound.—Upper right abdomen; lateral. Operative findings.—Large

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jagged wound of liver; severe hæmorrhage. Operation.—Packing wound; drainage. Complications.—Wound infection; drained bile. Days in hospital.—Thirty.

CASE XLVII.—White man, twenty-seven years old. Operation, hours after injury.—? Location of wound.—Upper right and left abdomen. Operative findings.—Wound of left kidney; retroperitoneal hematoma; moderate hæmorrhage. Operation.—Exploratory laparotomy; suture of kidney. Days in hospital.—Twenty-four.

CASE XLVIII.—Colored man, thirty-one years old. Operation, hours after injury.—One and one-quarter. Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver; moderate hæmorrhage. Operation.—Packing; drainage; reinfusion or replacement of 300 cubic centimetres blood. Complications.—Pneumonia. Days in hospital.—Forty.

CASE XLIX.—White man, twenty-nine years old. Operation, hours after injury.—One. Location of wound.—Right lateral abdomen; flank. Operative findings.—Nine perforations ileum and jejunum; injury to mesentery of ascending colon; severe hæmorrhage. Operation.—Enterorrhaphy; suture; drainage. Complications.—Fracture head of left humerus. Days in hospital.—Twenty-five.

CASE L.—Colored woman, thirty years old. Operation, hours after injury.—Ten (refused early operation). Location of wound.—Lower right abdomen; anterior. Operative findings.—No visceral injury; slight hæmorrhage. Operation.—Exploratory laparotomy; X-ray disclosed bullet lodged in uterus. Days in hospital.—Twenty-three.

CASE LI.—Colored man, twenty-two years old. Operation, hours after injury.—? Location of wound.—Upper right abdomen. Operative findings.—Ten perforations of small intestine; severe hæmorrhage; injury to mesentery. Operation.—Enterorrhaphy. Days in hospital.—Twenty-six.

CASE LII.—White man, nineteen years old. Operation, hours after injury.—One. Location of wound.—Upper right abdomen; lateral. Operative findings.—Wound of liver; two perforations of stomach; injury to mesentery; moderate hæmorrhage. Operation.—Gastrorrhaphy; suture; packing liver wound; drainage. Complications.—Wound infection. Days in hospital.—Thirty-two.

CASE LIII.—White man, twenty-five years old. Operation, hours after injury.—Fourteen and one-half. Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver and diaphragm; severe hæmorrhage. Operation.—Packing liver wound; drainage; laparotomy. Days in hospital.—Twenty-two.

CASE LIV.—Colored woman, twenty-four years old. Operation, hours after injury.—Twenty-one. Location of wound.—Lower abdomen; anterior. Operative findings.—Wound of bladder. Operation.—Exploratory laparotomy; suture; drainage. Days in hospital.—Forty-three.

CASE LV.—Colored man, twenty-three years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper left abdomen; anterior. Operative findings.—Nine perforations of small intestine; ileum; slight hæmorrhage. Operation.—Enterorrhaphy drainage. Days in hospital.—Fourteen.

CASE LVI.—White boy, thirteen years old. Operation, hours after injury.—One and one-quarter. Location of wound.—Upper left abdomen; anterior. Operative findings.—Wound of liver; contusions small intestines; two perforations transverse colon; slight hæmorrhage. Operation.—Enterorrhaphy; drainage; suture. Days in hospital.—Thirty.

CASE LVII.—White boy, eight years old. Operation, hours after injury.—One and one-quarter. Location of wound.—Upper abdomen; anterior. Operative findings.—Wound of liver; pancreas; two perforations of stomach; severe hæmorrhage. Operation.—Gastrorrhaphy; pack liver wound; drainage. Days in hospital.—Forty-four.

CASE LVIII.—White woman, twenty-six years old. Operation, hours after injury.—Four and three-quarters. Location of wound.—Lower abdomen; posterior. Operative findings.—Two perforations small intestine; two of large intestine; slight hæmorrhage;

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laceration left ovary. Operation.—Enterorrhaphy; suture; drainage. Days in hospital.—Twenty-seven.

CASE LIX.—White man, thirty years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper left abdomen; anterior. Operative findings.—Ten perforations small intestine; two of large intestine; severe hæmorrhage. Operation.—Enterorrhaphy; drainage; suture; transfusion. Days in hospital.—Twenty-five.

### *Gunshot Wound Injuries—No Operation—Recovery*

CASE I.—White man, thirty-eight years old. Multiple bullet wounds. Admitted with signs of hæmorrhage; conservative treatment instituted; condition steadily improved. Probably wound of spleen with no other visceral injuries. Recovery, thirty-eight days.

CASE II.—White man, thirty-one years old. Single wound upper abdomen. No signs of perforation on admission; vomited blood on third day; condition had improved so much that conservative treatment was continued. Probably wound of stomach.

### *Gunshot-wound Injuries—Operation—Death*

CASE I.—White man, twenty-eight years old. Operation, hours after injury.—One and one-quarter. Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver; diaphragm and pleura; severe hæmorrhage. Operation.—Exploratory laparotomy; packing; drainage; irrigation N. S. S. Time and autopsy cause of death.—Twenty-seven hours; hemothorax; hæmorrhage; early peritonitis.

CASE II.—White man, forty-three years old. Operation, hours after injury.—Twelve. Location of wound.—Upper left abdomen; anterior. Operative findings.—Wound of liver; two perforations of stomach; three of small intestine; severe hæmorrhage. Operation.—Gastrorrhaphy; enterorrhaphy; suture; packing; irrigation N. S. S.; drainage. Time and cause of death.—Forty-six days; subphrenic abscess; no autopsy.

CASE III.—White boy, four years old. Operation, hours after injury.—One and one-quarter. Location of wound.—Lower right abdomen; anterior. Operative findings.—Eleven perforations of small intestine; moderate hæmorrhage. Operation.—Enterorrhaphy; irrigation N. S. S.; drainage. Time and autopsy cause of death.—Thirty-six hours; early peritonitis; acute dilatation of heart.

CASE IV.—White man, twenty-six years old. Operation, hours after injury.—One. Location of wound.—Upper right abdomen; lateral. Operative findings.—Wound of liver and duodenum; injury to transverse mesocolon; moderate hæmorrhage. Operation.—Enterorrhaphy; suture; drainage. Complication.—General peritonitis. Time and autopsy cause of death.—Thirteen days; right subphrenic abscess; peritonitis; duodenal repairs not holding; gangrene and sloughing of retroperitoneal structures; gas-bacillus infection?

CASE V.—White man, twenty-one years old. Operation, hours after injury.—Eighteen. Location of wound.—Upper right abdomen; lateral. Operative findings.—Wound of liver; two perforations of stomach; severe hæmorrhage; injury to diaphragm. Operation.—Gastrorrhaphy; drainage. Time and autopsy cause of death.—Two hours after operation; hæmorrhage and shock.

CASE VI.—White man, thirty years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver, diaphragm and pleura; abdomen filled with blood; severe hæmorrhage. Operation.—Exploratory laparotomy; packing; drainage. Time and autopsy cause of death.—Nine hours; hæmorrhage and shock; no autopsy.

CASE VII.—Colored woman, twenty-four years old. Operation, hours after injury.—Two. Location of wound.—Upper left abdomen; lateral. Operative findings.—Two perforations of diaphragm; pleura; lungs; bleeding at root of mesentery into lesser peritoneal cavity. Operation.—Exploratory laparotomy; packing; drainage. Complica-

tion.—Local peritonitis. Time and autopsy cause of death.—Twenty-four days; sub-phrenic abscess; perforation of posterior wall of stomach and liver overlooked; sepsis.

CASE VIII.—Colored man, twenty-four years old. Operation, hours after injury.—Two. Location of wound.—Upper left abdomen; lat-ral. Operative findings.—Two perforations of stomach; two of small intestine; two of ascending colon; severe hæmorrhage. Operation.—Gastrorrhaphy; enterorrhaphy; suture; ligation; drainage. Time and autopsy cause of death.—Twelve hours; hæmorrhage and shock.

CASE IX.—White woman, forty years old. Operation, hours after injury.—One and three-quarters. Location of wound.—Lower right abdomen; lateral. Operative findings.—Wound of liver; moderate hæmorrhage. Operation.—Exploratory laparotomy; suture. Complication.—Early peritonitis. Time and autopsy cause of death.—Two and one-half days; hæmorrhage; peritonitis; chronic nephritis.

CASE X.—Colored man, thirty-two years old. Operation, hours after injury.—Two. Location of wound.—Upper right abdomen; anterior. Operative findings.—Thirteen perforations small intestine; two of large intestine; lacerations mesentery; moderate hæmorrhage. Operation.—Enterorrhaphy; suture; drainage; irrigation N. S. S. Time and autopsy cause of death.—Two and one-half days; hæmorrhage; peritonitis; chronic alcoholic nephritis.

CASE XI.—White man, thirty-two years old. Operation, hours after injury.—Two. Location of wound.—Upper right abdomen; lateral. Operative findings.—Perforating wound of liver; severe hæmorrhage; cavity filled with blood. Operation.—Exploratory laparotomy; packing; drainage. Time and autopsy cause of death.—Forty hours; profuse hæmorrhage; shock; early peritonitis. One perforation stomach; one of spleen; two of diaphragm overlooked.

CASE XII.—White man, thirty-five years old. Operation, hours after injury.—Two. Location of wound.—Upper right abdomen; anterior. Operative findings.—Eleven perforations of small intestine; severe hæmorrhage. Operation.—Enterorrhaphy; drainage. Time and autopsy cause of death.—Twenty-three hours; rapid peritonitis; hæmorrhage.

CASE XIII.—White man, fifty years old. Operation, hours after injury.—Three-quarters. Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver; two perforations stomach through pylorus; laceration of mesentery; wound of pancreas; severe hæmorrhage. Operation.—Gastrorrhaphy; packing; drainage. Time and autopsy cause of death.—Nine hours; hæmorrhage; shock.

CASE XIV.—Colored man, forty-five years old. Operation, hours after injury.—One. Location of wound.—Upper left abdomen; anterior. Operative findings.—Wound of liver and diaphragm; severe hæmorrhage; probable injury to spinal cord. Operation.—Exploratory laparotomy; packing; drainage. Complications.—Retention of urine; incontinence of fæces; anæsthesia and paralysis both legs to knee. Time and autopsy cause of death.—Sixteen days; peritonitis; urinary-tract sepsis; injury to pancreas overlooked.

CASE XV.—White woman, twenty-nine years old. Operation, hours after injury.—? Location of wound.—Upper abdomen. Operative findings.—Eleven perforations to small intestine; injury to mesentery; severe hæmorrhage. Operation.—Enterorrhaphy; drainage. Time and autopsy cause of death.—Fourteen hours; hæmorrhage; shock.

CASE XVI.—White man, twenty-two years old. Operation, hours after injury.—One and one-half. Location of wound.—Anterior abdomen through umbilicus. Operative findings.—Two perforations small intestine; moderate hæmorrhage. Operation.—Enterorrhaphy; suture; drainage. Time and autopsy cause of death.—Thirty-two hours; hæmorrhage; rapid peritonitis.

CASE XVII.—Colored man, twenty-one years old. Operation, hours after injury.—Two. Location of wound.—Lower left abdomen; anterior. Operative findings.—Six perforations small intestine; laceration of mesentery; severe hæmorrhage. Operation.—Enterorrhaphy; suture; drainage. Time and autopsy cause of death.—Five days; general peritonitis; retroperitoneal hæmorrhage.

CASE XVIII.—White man, twenty-four years old. Operation, hours after injury.—?



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Location of wound.—Anterior abdomen. Operative findings.—Six perforations small intestine; one of mesentery; severe hæmorrhage. Operation.—Enterorrhaphy; suture; drainage; irrigation N. S. S. Complication.—General peritonitis. Time and autopsy cause of death.—Eight days; general peritonitis; secondary pericarditis.

CASE XIX.—White man, thirty-two years old. Operation, hours after injury.—Two. Location of wound.—Lower right abdomen; lateral. Operative findings.—Five perforations small intestine; two of cæcum; hematoma root of mesentery; laceration right external iliac vessels; severe hæmorrhage. Operation.—Enterorrhaphy; suture; drainage with vaseline gauze. Time and autopsy cause of death.—Two hours after operation; hæmorrhage; shock.

CASE XX.—Colored man, thirty-eight years old. Operation, hours after injury.—One and one-half to two. Location of wound.—Lower left abdomen; anterior. Operative findings.—Seven perforations small intestine; injury of mesentery; severe hæmorrhage; perforation external iliac vein. Operation.—Enterorrhaphy; resection and lateral anastomosis; suture; ligation; drainage. Time and autopsy cause of death.—Four hours; hæmorrhage; shock.

CASE XXI.—Woman, twenty-four years old. Operation, hours after injury.—? Location of wound.—Upper left abdomen; anterior; right chest; posterior. Operative findings.—Two perforations jejunum; one of transverse colon; one of ascending colon; wound of diaphragm; right lung; moderate hæmorrhage. Operation.—Enterorrhaphy; suture, drainage with vaseline gauze. Complications.—General peritonitis; purulent drainage from wound. Time and autopsy cause of death.—Forty-eight hours; hæmorrhage; peritonitis; pneumothorax; leakage colon sutures.

CASE XXII.—White woman, nineteen years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver and diaphragm; severe hæmorrhage. Operation.—Exploratory laparotomy; packing; drainage; transfusion. Time and autopsy cause of death.—Twelve hours; hæmorrhage; shock; no autopsy.

CASE XXIII.—White man, twenty-six years old. Operation, hours after injury.—One and three-quarters. Location of wound.—Upper right abdomen; lateral. Operative findings.—Wound of liver; severe hæmorrhage. Operation.—Exploratory laparotomy; packing; drainage. Time and autopsy cause of death.—Twenty-six hours; hæmorrhage; shock; hemopneumothorax. Wound of right kidney, diaphragm and right lung overlooked.

CASE XXIV.—White man, thirty-nine years old. Operation, hours after injury.—? Location of wound.—Upper left abdomen; anterior; left chest; anterior. Operative findings.—Two perforations small intestine; omentum perforated several places; severe hæmorrhage; wound of diaphragm; left lung. Operation.—Enterorrhaphy; ligation; drainage. Time and autopsy cause of death.—Three and one-half hours after operation; hæmorrhage; shock. Wounds in small intestine overlooked.

CASE XXV.—Colored man, forty-three years old. Operation, hours after injury.—Twelve. Location of wound.—Left abdomen; anterior. Operative findings.—One perforation of stomach near cardia (anterior wall); wound of diaphragm; left lung; wound in omentum. Operation.—Gastrorrhaphy; suture of omentum; drainage lesser peritoneal cavity. Time and autopsy cause of death.—Twelve hours; hæmorrhage; shock. Posterior wall stomach, wound of spleen, left kidney all overlooked.

CASE XXVI.—White man, fifty-two years old. Operation, hours after injury.—One and three-quarters. Location of wound.—Upper left abdomen, lateral. Operative findings.—Wound of liver; two perforations of stomach; severe hæmorrhage. Operation.—Gastrorrhaphy; suture; packing; drainage. Complication.—Local peritonitis. Time and autopsy cause of death.—Forty-two hours; peritonitis; hæmorrhage; pneumonia.

CASE XXVII.—White man, twenty-seven years old. Operation, hours after injury.—? Location of wound.—Upper left abdomen; lateral. Operative findings.—



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Wound of pancreas; two perforations of stomach; two of small intestine; severe hæmorrhage. Operation.—Gastrorrhaphy; enterorrhaphy; drainage. Time and autopsy cause of death.—Twelve hours after operation; pulmonary œdema; hæmorrhage; shock. Wound of liver and left kidney overlooked.

CASE XXVIII.—White man, twenty-two years old. Operation, hours after injury.—? Location of wound.—Upper left abdomen from back. Operative findings.—No visceral injury; wound of aorta. Operation.—Exploratory laparotomy; control of hæmorrhage with clamps; drainage. Time and autopsy cause of death.—Eight hours; hæmorrhage; shock.

CASE XXIX.—Colored man, forty-two years old. Operation, hour after injury.—One. Location of wound.—Lower right abdomen; lateral; multiple. Operative findings.—Two perforations stomach; two of jejunum; severe hæmorrhage. Operation.—Gastrorrhaphy; enterorrhaphy; suture; drainage. Time and autopsy cause of death.—Three days; hæmorrhage; pneumonia; no autopsy.

CASE XXX.—Colored man, thirty-eight years old. Operation, hour after injury.—One. Location of wound.—Upper left abdomen; lateral to right. Operative findings.—Wound of liver; gall-bladder; five perforations small intestine; two of transverse colon; severe hæmorrhage. Operation.—Enterorrhaphy; packing; drainage. Complication.—Peritonitis. Time and autopsy cause of death.—Five days; peritonitis; hæmorrhage; gall-bladder; sutures leaking.

CASE XXXI.—White man, thirty-eight years old. Operation, hours after injury.—One. Location of wound.—Upper left abdomen, anterior. Operative findings.—Wound of left kidney; two perforations stomach; injury to mesentery; severe hæmorrhage. Operation.—Nephrectomy, gastrorrhaphy; drainage; suture; ligation; transfusion. Time and autopsy cause of death.—One day; hæmorrhage; shock. Wound to pancreas overlooked. Condition critical at operation.

CASE XXXII.—Colored man, thirty-seven years old. Operation, hours after injury.—One and one-quarter. Location of wound.—Upper right abdomen; anterior. Operative findings.—Four perforations ileum; three of cæcum; slight hæmorrhage. Operation.—Enterorrhaphy; suture; drainage. Complication.—General peritonitis. Time and autopsy cause of death.—Five days; hæmorrhage; general peritonitis.

CASE XXXIII.—Colored man, thirty-eight years old. Operation, hours after injury.—One and three-quarters. Location of wound.—Upper left abdomen. Operative findings.—Two perforations jejunum; one of ileum; three of descending colon at mesenteric border; slight hæmorrhage. Operation.—Enterorrhaphy; suture; drainage. Time and autopsy cause of death.—Four hours; hæmorrhage; alcoholism; shock.

CASE XXXIV.—Colored man, thirty-three years old. Operation, hours after injury.—One and one-half. Location of wound.—Upper right abdomen; anterior; multiple. Operative findings.—Four perforations small intestine one of cæcum; two descending colon; several of mesentery; two of omentum; severe hæmorrhage. Operation.—Enterorrhaphy; resection small intestine; lateral anastomosis; cecostomy; suture; ligation; drainage. Time and autopsy cause of death.—thirty-six hours; hæmorrhage; shock; peritonitis.

CASE XXXV.—White man, forty years old. Operation, hours after injury.—Twenty-seven. Location of wound.—Upper right abdomen, lateral from back. Operative findings.—Severe wound of liver; four perforations of mesentery; severe hæmorrhage. Operation.—Laparotomy; packing; drainage. Complications.—Considerable wound bleeding on coughing. Time and autopsy cause of death.—twelve hours; hæmorrhage; shock; early peritonitis. Wound of duodenum overlooked.

CASE XXXVI.—White woman, twenty-five years old. Operation, hours after injury.—Four. Location of wound.—Lower abdomen; right chest. Operative findings.—Wound of liver; two perforations stomach; four of transverse colon; severe hæmorrhage. Operation.—Gastrorrhaphy; enterorrhaphy; suture; transfusion. Complication.—Cystitis;

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nephritis; hemothorax. Time and autopsy cause of death.—five days; septicemia? hæmorrhage; no autopsy.

CASE XXXVII.—White woman, forty-nine years old. Operation, hours after injury.—?. Location of wound.—Right abdomen; lateral; right chest. Operative findings.—Perforation of uterus; four of small intestine; four of large; severe hæmorrhage; wound of bladder and pleura. Operation.—Enterorrhaphy; suture; drainage. Time and autopsy cause of death.—ten hours; hæmorrhage; shock.

CASE XXXVIII.—White man, seventeen years old. Operation, hours after injury.—Eight? Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver; moderate hæmorrhage. Operation.—Laparotomy; suture; ligation; drainage. Complication.—Wound infected; bronchopneumonia; pleural effusion. Time and autopsy cause of death.—Twenty-one days; liver abscess; pneumonia; pleurisy; septicemia.

CASE XXXIX.—White man, twenty-eight years old. Operation, hours after injury.—Two. Location of wound.—Upper left abdomen; lateral; left upper abdomen; posterior. Operative findings.—Wound of liver; left kidney; two perforations stomach; wound of diaphragm; wound of lung; severe hæmorrhage. Operation.—Gastrorrhaphy; suture; drainage. Complication.—Rupture of wound. Time and autopsy cause of death.—Eighteen hours; hæmorrhage; shock; early peritonitis.

CASE XL.—Colored man, twenty-four years old. Operation, hour after injury.—One. Location of wound.—Right abdomen; posterior; left chest. Operative findings.—Wound of liver; right kidney; right lung; diaphragm; severe hæmorrhage. Operation.—Laparotomy; packing; drainage; transfusion. Time and autopsy cause of death.—Twenty-four hours; early sepsis; hæmorrhage, shock.

CASE XLI.—Man. Operation, hours after injury.—?. Location of wound.—Upper right abdomen; anterior. Operative findings.—Wound of liver; four perforations large intestine; severe hæmorrhage. Operation.—Enterorrhaphy; suture; drainage. Time and autopsy cause of death.—Fifteen hours; hæmorrhage; shock; early peritonitis.

CASE XLII.—White man, thirty-nine years old. Operation, hours after injury.—?. Location of wound.—Upper left abdomen; lateral; multiple. Operative findings.—Wound of liver; two perforations stomach; moderate hæmorrhage; diaphragm injured. Operation.—Gastrorrhaphy; no drainage. Time and autopsy cause of death.—Three days; bilateral hemothorax peritonitis; hæmorrhage.

CASE XLIII.—Colored man, twenty-four years old. Operation, hours after injury.—Three. Location of wound.—Upper lower left abdomen; anterior; multiple. Operative findings.—Three perforations small intestine; two of sigmoid; severe hæmorrhage. Operation.—Enterorrhaphy; drainage. Time and autopsy cause of death.—three and one-half hours after operation; hæmorrhage; shock.

CASE XLIV.—Colored man, forty-nine years old. Operation, hours after injury.—?. Location of wound.—Lower left abdomen; lateral. Operative findings.—Hematoma retroperitoneal at sigmoid; three contusions serous coat sigmoid; fracture sacrum; slight hæmorrhage. Operation.—Laparotomy; no drainage; second operation forty days later; thoracotomy. Complication.—Rupture of wound; lung abscess; empyema; septicemia; Brown Sequard syndrome. Time and autopsy cause of death.—Fifty days; septicemia; blood culture positive.

CASE XLV.—Colored man, thirty-two years old. Operation, hours after injury.—Three and one-half. Location of wound.—Upper right abdomen; lateral. Operative findings.—Wound of liver; massive hæmorrhage; cavity filled with blood. Operation.—Laparotomy; packing; drainage. Time and autopsy cause of death.—One-half hour after operation; hæmorrhage; shock. Wound right kidney and stomach overlooked.

CASE XLVI.—White man, thirty years old. Operation, hours after injury.—Four and one-half. Location of Wound.—Lower left abdomen. Operative findings.—Wound of spleen; severe hæmorrhage; wound of diaphragm. Operation.—Splenectomy;

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no drainage. Time and autopsy cause of death.—Fifteen hours after operation; hæmorrhage; shock. Wound of liver overlooked.

CASE XLVII.—Colored man, twenty-one years old. Operation, hours after injury.—Two. Location of wound.—Upper left abdomen; multiple. Operative findings.—Two perforations stomach; two of small intestine; two descending colon; tearing wounds of colon at edge; severe hæmorrhage. Operation.—Gastrorrhaphy; enterorrhaphy; suture; drainage. Time and autopsy cause of death.—Twenty-four hours; hæmorrhage; shock; early peritonitis.

CASE XLVIII.—Colored woman, twenty-six years old. Operation, hours after injury.—Five. Location of wound.—Upper left abdomen; lateral. Operative findings.—Eight perforations ileum; one of mesentery; two of colon. Operation.—Enterorrhaphy; suture. Complication.—Local peritonitis; infected wound. Time and autopsy cause of death.—Nine days; died suddenly; peritonitis; embolus?, leakage from colon repair.

CASE XLIX.—Colored man, forty-eight years old. Operation, hours after injury.—Three and one-half. Location of wound.—Lower right abdomen. Operative findings.—Penetrating wound of abdomen; severe hæmorrhage; laceration external iliac vein and artery. Operation.—Laparotomy; ligation; drainage. Time and autopsy cause of death.—On table; hæmorrhage.

CASE L.—White man, fifty-two years old. Operation, hours after injury.—Two. Location of wound.—Lower left abdomen; anterior. Operative findings.—Three perforations ileum; three of mesentery; severe hæmorrhage. Operation.—Enterorrhaphy; suture; ligation; drainage; transfusion. Time and autopsy cause of death.—Twelve hours; hæmorrhage; no autopsy.

CASE LI.—Colored man, twenty-nine years old. Operation, hour after injury.—One-half. Location of wound.—Lower right abdomen; lateral. Operative findings.—Four perforations small intestine; wound of bladder; severe hæmorrhage; fracture right ileum. Operation.—Laparotomy; marsupialization of bladder. Time and autopsy cause of death.—Three days; hæmorrhage; sepsis.

CASE LII.—Colored man, thirty-four years old. Operation, hours after injury.—Four. Location of wound.—Left abdomen; lateral; multiple. Operative findings.—Seven perforations jejunum. Operation.—Enterorrhaphy; drainage. Complication.—Infected wound; lobar pneumonia. Time and autopsy cause of death.—Five days; Pneumonia; peritonitis.

CASE LIII.—Colored man, thirty-seven years old. Operation, hours after injury.—Two and one-half. Location of wound.—Upper left abdomen; anterior; right chest, anterior. Operative findings.—Six perforations jejunum; one of ascending colon; superior mesentery artery severed; severe hæmorrhage. Operation.—Laparotomy. Complication.—Right hemothorax. Time and autopsy cause of death.—On table, hæmorrhage.

CASE LIV.—White man, fifty-five years old. Operation, hours after injury.—Fifty. Location of wound.—Upper left abdomen. Operative findings.—One perforation jejunum. Operation.—Enterorrhaphy. Complication.—General peritonitis. Time and autopsy cause of death.—On table; peritonitis; hæmorrhage.

CASE LV.—Colored woman, twenty-four years old. Operation, hours after injury.—Two and one-half. Location of wound.—Right flank. Operative findings.—Six perforations small intestine; three of descending colon; several lacerations mesentery; severe hæmorrhage. Operation.—Enterorrhaphy; suture; drainage. Time and autopsy cause of death.—Nine hours; hæmorrhage; shock; early peritonitis.

### *Gunshot-wound Injuries—No Operation—Death*

CASE I.—White boy, eighteen years old. Condition on admission.—Moribund. Time and autopsy cause of death.—Ten minutes; hæmorrhage and shock; wound of pyloric end of stomach; vessels in front of spine.

CASE II.—White man, twenty-six years old. Condition on admission.—Moribund.

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Time and autopsy cause of death.—Five minutes; hæmorrhage and shock; branches of aorta severed.

CASE III.—White man, forty years old. Condition on admission.—Moribund. Time and autopsy cause of death.—Few minutes; hæmorrhages and shock; six perforations small intestine; six in mesentery.

CASE IV.—Colored man, thirty-two years old. Condition on admission.—Moribund. Time and autopsy cause of death.—?; hæmorrhage and shock; injuries to stomach, diaphragm, liver, pancreas and duodenum.

CASE V.—Colored woman. Condition on admission.—Moribund. Time and autopsy cause of death.—Forty minutes; hæmorrhage and shock; left pleural cavity filled with blood; wounds of abdomen, chest and left hand. Six hundred cubic centimetres N. S. S. given intravenously.

CASE VI.—White man, twenty-eight years old. Condition on admission.—Moribund. Time and autopsy cause of death.—Few minutes; hæmorrhage and shock; no autopsy.

CASE VII.—White man, fifty years old. Condition on admission.—Suicide. Time and autopsy cause of death.—Five days; cardiac decompensation; passed bloody urine; pneumonia; peritonitis ?; no autopsy.

CASE VIII.—Colored woman, thirty-two years old. Condition on admission. Moribund. Time and autopsy cause of death.—Twenty-six hours; shock and multiple injuries; two perforating wounds of cranium, two penetrating wounds of abdomen; no autopsy.

CASE IX.—White man. Condition on admission.—Moribund. Time and autopsy cause of death.—Thirty minutes; hæmorrhage and shock; wound of right lung; several of liver; multiple of intestines; wounds of vessels in front of spine.

CASE X.—White man, forty-eight years old. Condition on admission.—Moribund. Time and autopsy cause of death.—Few minutes; hæmorrhage and shock; perforation of intestines; liver and gall-bladder.

CASE XI.—Colored man, thirty-four years old. Condition on admission.—Moribund. Time and autopsy cause of death.—Few minutes; hæmorrhage and shock; injury to left lung; both ventricles of heart, liver, vena cava.

CASE XII.—White man, thirty-one years old. Condition on admission.—Moribund. Time and autopsy cause of death.—Few minutes; hæmorrhage and shock; injury to liver, diaphragm.

CASE XIII.—White man, twenty-five years old. Condition on admission.—Moribund. Time and autopsy cause of death.—Five minutes; hæmorrhage and shock; no autopsy.

CASE XIV.—White man, thirty-one years old. Condition on admission.—Moribund. Time and autopsy cause of death.—Few minutes; hæmorrhage and shock; iliac vessels severed.

CASE XV.—Colored man, twenty-three years old. Condition on admission.—Moribund. Time and autopsy cause of death.—One hour; hæmorrhage and shock; wounds of liver and pancreas.

CASE XVI.—Colored man, fifty years old. Condition on admission.—Moribund. Time and autopsy cause of death.—One hour; hæmorrhage and shock; iliac vessels severed.

CASE XVII.—White man, thirty-four years old. Condition on admission.—Moribund. Time and autopsy cause of death.—Two and one-half hours; hæmorrhage and shock; wounds of liver and stomach; did not respond to resuscitating measures.

CASE XVIII.—White man, thirty years old. Condition on admission.—Moribund. Time and autopsy cause of death.—One hour; hæmorrhage and shock; abdomen filled with blood.

CASE XIX.—White man, thirty-two years old. Condition on admission.—Moribund. Time and autopsy cause of death.—One hour; hæmorrhage and shock; no autopsy. One thousand cubic centimetres N. S. S. given.

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CASE XX.—White man, twenty-three years old. Condition on admission.—Moribund. Time and autopsy cause of death.—Two hours; hæmorrhage and shock; large liver wound; grazed side of upper lumbar spine; blood in abdomen.

The liver was injured in 22 cases (no associated injuries in 11)  
 The stomach was injured in 9 cases (no associated injuries in 1)  
 The small intestine was injured in 18 cases (no associated injuries in 8)  
 The large intestine was injured in 8 cases (no associated injuries in 3)  
 The spleen was injured in 3 cases (no associated injuries in 2)  
 The pancreas was injured in 2 cases  
 The kidney was injured in 3 cases (no associated injuries in 1)  
 The bladder was injured in 3 cases (no associated injuries in 2)  
 The ureter was injured in 1 case

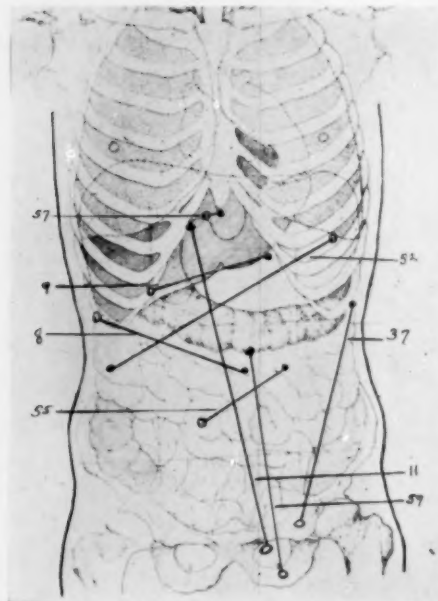


FIG. 1.—Gunshot wounds—operative recoveries. ●—Wound of entrance. ○—Wound of exit. ⊙—Posterior wound. Numbers refer to numbers in respective charts.

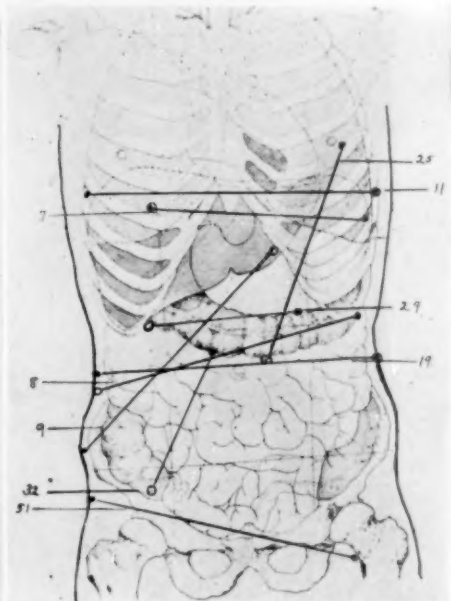


FIG. 2.—Gunshot wounds—operative deaths. ●—Wound of entrance. ○—Wound of exit. ⊙—Posterior wound. Numbers refer to numbers in respective charts.

Resection of the small intestine was done in 3 cases (with end-to-end anastomosis in two and lateral anastomosis in one). A lateral anastomosis without resection was done in one case. Splenectomy was done in one patient who developed tertian malaria during convalescence. Nephrectomy was done in one case. Two cases were transfused, and a re-infusion or replacement of 300 cubic centimetres of blood was done in a case of liver injury.

Ten cases suffered wound infection, 3 of these occurring in 6 patients whose wounds were closed without drainage. Three had general peritonitis, one had local peritonitis, and four had pneumonia.

Two patients recovered without operation who were thought to have had visceral injury. One was in a state of collapse on admission, with all the signs of massive internal hæmorrhage. The pulse was imperceptible, blood



## PENETRATING WOUNDS OF THE ABDOMEN

pressure 60/40, and his general condition so serious that operation was postponed and conservative treatment instituted. His condition had improved so much at the end of twenty-four hours that conservative treatment was continued. The injury was thought to have been one of the spleen. He developed a small left pleural effusion (hæmolytic streptococci on culture from aspirated fluid) with moderate fever for four weeks, and recovered in thirty-eight days. In reference to the other case, it was thought that he did not suffer intra-abdominal injury at the time of admission, but he vomited a considerable quantity of blood on the third day, and developed symptoms of peritonitis with obliteration of liver dullness, marked rigidity and tenderness, when a diagnosis of perforation of stomach was made.

Conservative treatment was continued with gradual improvement of his symptoms until recovery.

*Gunshot Deaths.*—In this group there were 75 cases, 20 of which were not operated upon for the reason that they were moribund on admission or were never in condition for operation—the table is explanatory. Fifty-five cases were operated upon, 28 of which died within twenty-four hours. Hæmorrhage was severe in 42 cases, and was severe in all who died within twenty-four hours. Fifty-three cases suffered visceral injury. In 2 cases there was no visceral injury, but in each of these there was large blood-vessel damage (abdominal aorta, one; right external iliac vessels, one). It will be seen in the tabulations that multiple visceral and associated visceral injury was present in nearly all of the cases. In the majority of these it was of an extensive nature.

The liver was injured in 23 cases (no associated injuries in 2)

The stomach was injured in 16 cases

The small intestine was injured in 30 cases (no associated injuries in 10)

The large intestine was injured in 16 cases (no associated injuries in 1)

The kidney was injured in 7 cases

The spleen was injured in 3 cases

The pancreas was injured in 3 cases

The bladder was injured in 2 cases

The external iliac vessels were injured in 3 cases (no associated injuries in 1)

The abdominal aorta was injured in 1 case

There were 18 cases with combined abdominal and chest injuries. Five patients were transfused. Intestinal resection was done in 2 cases, nephrectomy in one, and splenectomy in one.

We have autopsy reports on 49 of the 55 gunshot operative deaths checked against operative findings in tabulation of cases. The records revealed that in 9 cases visceral injuries of one kind or another had been overlooked at the time of operation. It is difficult to say what part was played by the unrepaired injuries in the cause of death, but we believe it was an important one. Five of the 9 cases died within twenty-four hours, all attributed to hæmorrhage and shock. The overlooked injuries in these cases included stomach and right kidney in one (45)\*, stomach (posterior

\* Refers to case numbers in tabulation.

wall), spleen and left kidney in one (25)\*, duodenum in one (35)\*, pancreas in one (31)\*, and left kidney and liver in one (27)\*. In another case with severe hæmorrhage from a liver injury, wounds of the right kidney, diaphragm and right lung (23)\* were overlooked. Death occurred in twenty-six hours from hæmorrhage and shock. In another case with overlooked wounds of stomach, spleen and diaphragm (11)\* death occurred in forty hours from hæmorrhage and shock. A wound of the pancreas (14)\* was overlooked in a case of liver, diaphragm and cord injury with severe hæmorrhage. Death occurred in sixteen days from peritonitis and urinary-tract infection. Another case (7) in whom a wound of the liver and posterior wall of the stomach was overlooked lived for twenty-four days. Sub-phrenic abscess and sepsis was the cause of death. In three cases (4, 21, 48)\* that died of peritonitis or infection, leakage had occurred subsequent to the repair of perforating wounds of the intestine (duodenum, 1; colon, 2), and probably in each instance was a big factor, if not the direct cause, of death.

In regard to the overlooked injuries, we believe that their occurrence is more common than is generally supposed. The most convincing proof of the correctness of this statement will come from an autopsy "check-up" with operative findings. Those who have had experience in dealing with injuries such as are represented in this group of operative deaths will appreciate the difficulties often encountered at operation, and the ease with which such an error may be committed. The 9 cases in which lesions were overlooked were in very critical condition at the time of operation. Several of them had failed to show any reaction from shock after the use of the usual anti-shock measures, and their condition had rapidly changed from bad to worse because of continued bleeding, the operation having been done primarily for the control of hæmorrhage. Under such circumstances the amount of the anæsthetic and the time required for the operation assume more than the usual importance in the result. It is in such cases that blood transfusion will be of the greatest value. By this means the patient's condition may be so improved that the surgeon can go ahead with a thoroughly satisfactory exploration, and a careful repair of all visceral injuries. The average time between injury and operation for the whole series was a little over three hours, which we believe is early enough. More errors are made in operating too soon than too late. It is important to give the patient a chance to react from shock. Hæmorrhage must be differentiated from shock, and a distinction must be made in the patients whose failure to react is due to continued bleeding. If the pulse is rapid (120 or above), and its rate is not reduced by resuscitating shock measures, hæmorrhage of a serious character may be suspected.

In conclusion we suggest, *first*, the more general and routine use of blood transfusion, and in selected cases of severe hæmorrhage without hollow visceral injury, the re-infusion or replacement of blood can be done to great advantage. *Second*, the adoption of measures calculated to further reduce

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\* Refers to case numbers in tabulation.

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the incidence of intra-abdominal and wound infection. *Third*, thorough exploration of every case for visceral injury, particularly of the upper abdomen where the risk of overlooking injuries is greatest.

We wish to express our appreciation to Dr. W. S. Wadsworth, coroner's physician of Philadelphia, for the high percentage of autopsy records contained in this series.

### REFERENCES

- Wallace, Cuthbert: A Study of 1200 Cases of Gunshot Wounds of the Abdomen. *British Journ. of Surg.*, pp. 679-743, 1916-1917.
- Lockwood, A. L., Kennedy, C. M., *et al.*: The Treatment of Gunshot Wounds of the Abdomen. *British Med. Journ.*, p. 317, March 10, 1917.
- Bivings, Charles: Treatment of Gunshot Wounds of the Abdomen. *Journ. of the Med. Assoc. of Georgia*, pp. 166-169, May, 1927.
- Miller, Martin O.: Gunshot Wounds of the Abdomen. *New Orleans Med. and Surg. Journ.*, pp. 279-283, November, 1927.
- Loria, Frank L.: Visceral Injuries in Gunshot Wounds of the Abdomen. *New Orleans Med. and Surg. Journ.*, pp. 283-287, November, 1927.
- Mason, James Monroe: Hæmorrhage in Injuries of the Abdomen. *ANNALS OF SURGERY*, p. 382, March, 1924.
- McKeithen, Archibald: Penetrating Wounds of the Abdomen—A Study of 69 Cases. *Kentucky Med. Journ.*, pp. 77-82, February, 1929.
- Condict, Woodhull Lee: Perforated Gunshot and Stab Wounds of the Abdomen. *ANNALS OF SURGERY*, p. 51, July, 1924.
- Winslow, Nathan: Penetrating Abdominal Wounds. *Surg., Gyn. and Obstet.*, p. 617, May, 1922.
- Fenner, E. D.: Gunshot Wounds of the Abdomen. *ANNALS OF SURGERY*, (quoted by Miller), January, 1902.

## THE EVALUATION OF RESULTS IN 324 GASTRIC AND DUODENAL ULCERS\*

By J. WILLIAM HINTON, M.D.  
OF NEW YORK, N. Y.

FROM THE FOURTH SURGICAL DIVISION OF BELLEVUE HOSPITAL

IN VIEW of the fact that most internists and surgeons are not in accord as to the permanency of cure after either medical or surgical treatment of ulcers, it was decided by Dr. Carl G. Burdick, Director of the Fourth Surgical Division, and Dr. Alexander Lambert, Director of the Fourth Medical Division, Bellevue Hospital, to organize a combined clinic for the study of this disease. This clinic was started in January, 1928, and the cases admitted for the first three years have been reviewed. During this period we have observed 324 ulcers and the cases have been divided into the month and year of admission to determine whether there has been a seasonal relationship to ulcer symptomatology. It was felt that by taking the admission to the clinic one could determine more accurately the month in which the patient had periodicity of pain, rather than by relying on the history, as all of these patients live in Greater New York and would enter the clinic when their pain was most intense. In reviewing the histories with symptoms extending over eight to ten years, the patient usually cannot recall the month, or even the exact year, of onset. In our review, there was no seasonal relationship except a slight decrease in the months of August and September. (See Table I.) The reason for the large number of admissions for January and February of 1928 was due to the fact that all ulcer cases treated on the Fourth Medical and Surgical Divisions for the past ten years were written to and asked to return for observation.

It is of interest to determine whether the incidence of ulcer is on the increase or decrease, and an analysis of the total number of ulcers and the total admissions to Bellevue Hospital, from 1910 to 1930 inclusive, reveals an increase in the total number of ulcer cases and when worked out on a percentage basis also reveals an increase which is illustrated in Table II. These statistics were taken from the annual report of the hospital. One question that naturally arises is whether the diagnosis is not more accurately made now than in the beginning of the series. There seems to be little doubt that the röntgen diagnosis is more accurate at present, but Hirsch introduced the double meal method of gastro-intestinal examination at Bellevue Hospital in 1910, but, of course, there were fewer cases to examine then than now. Also, refinements have been made in the technic of examination. The assumption that as many ulcers existed in 1910 as in 1930, but were unrecognized at that time, would lead one to believe that the complications of perforation and hæmorrhage should have been much more common twenty years

\* Read by title before the American Gastro-Enterological Association, May 5, 1931.

# TREATMENT RESULTS GASTRIC ULCERS

ago than now, but it is interesting to note on reviewing the perforated and hæmorrhaged cases on the Fourth Surgical Division that these complications have shown a marked increase in recent years. There have been 116 acute perforated ulcers on the Fourth Surgical Division from 1911 to 1930, inclusive, which is shown in Table III. It can be seen that from 1923 on there has been a marked increase in this complication and also during the past twenty years there have been fifty-seven cases of bleeding ulcer with an increase during the past three years. (See Table IV.) How to explain this apparent increase in the total number of cases and complications in recent years is very difficult, but the figures are taken from a city institution and it is fair to assume that the same type of patient was seen twenty years ago as at the present time and their habits of living have not changed appreciably during this period.

TABLE I  
*Shows Month and Year of Admission to Clinic*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
1928	15	20	10	11	17	6	10	2	7	3	11	12	124
1929	7	5	13	10	11	13	9	8	3	7	4	10	100
1930	11	5	13	8	8	4	4	3	6	17	13	8	100
Totals	33	30	36	29	36	23	23	13	16	27	28	30	324

TABLE II  
*Total Number of Admissions with Percentage of Ulcer Cases*

Year	Gastric	Deaths	Duodenal	Deaths	Total ulcers	Total admissions	Percentage of cases with ulcers
1910	29	4	...	..	33	36,330	.09
1911	48	6	...	..	54	37,578	.14
1912	39	8	...	..	47	40,296	.11
1913	56	10	...	..	66	41,248	.16
1914	55	8	...	..	53	43,297	.12
1915	73	7	23	4	107	44,485	.24
1916	108	16	50	4	178	45,422	.39
1917	88	17	62	7	174	45,470	.38
1918	89	11	55	4	159	42,563	.37
1919	71	6	34	1	112	38,850	.30
1920	61	10	43	3	115	38,945	.30
1921	59	15	56	5	135	43,597	.31
1922	79	13	81	7	180	45,671	.40
1923	75	13	101	10	199	45,258	.44
1924	137	9	148	5	299	49,344	.61
1925	119	16	164	10	309	49,511	.62
1926	115	16	138	8	277	48,293	.57
1927	88	20	151	11	270	49,986	.54
1928	143	21	198	11	373	52,336	.71
1929	114	21	158	17	310	52,643	.59
1930	123	21	212	10	335	57,292	.59



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This report will not take up the end-results of medical or surgical management as it is felt that no accurate conclusions can be drawn from either

TABLE III  
*Showing Year of Perforation*

Year	Died	Improved	Total
1911	0	1	1
1912	2	0	2
1913	1	2	3
1914	0	4	4
1915	2	1	3
1916	0	2	2
1917	3	3	6
1918	1	4	5
1919	1	3	4
1920	0	3	3
1921	1	2	3
1922	1	4	5
1923	3	6	9
1924	1	7	8
1925	0	8	8
1926	3	5	8
1927	0	9	9
1928	0	9	9
1929	1	12	13
1930	2	9	11
Total	22	94	116

treatment unless the patient has been observed for at least ten years, and frequently examined during this time. The patients seen in the clinic during

TABLE IV  
*Year in Which Hæmorrhage Occurred*

1911	4	1921	1
1912	1	1922	0
1913	2	1923	1
1914	1	1924	3
1915	1	1925	2
1916	1	1926	2
1917	0	1927	3
1918	1	1928	10
1919	0	1929	13
1920	0	1930	11
		Total	57

past three years have been grouped as to location of lesion, which is illustrated in Table V. During this period, 324 patients were seen and they have made a total of 3,452 visits. There were 214 unoperated cases in this group and

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TABLE V  
*Shows Location of Ulcer*

Duodenal	Gastric	Pyloric	Double ulcers (stomach and duodenum)	Total
270	34	14	6	324

we have referred only twenty for operation as the one indication for surgery is pain which cannot be relieved by different methods of medical care. During the three years there have been six acute perforated ulcers and five hæmorrhages occurring in patients under medical treatment. Of the perforations, two resulted in death and the others are progressing satisfactorily after simple closure. The bleeding cases are progressing satisfactorily after transfusions and conservative care. The question of carcinoma arising in ulcers is always an interesting topic for discussion. We have treated all ulcers, whether gastric or duodenal, by medical care and have been encouraged by the prompt response that is obtained in gastric lesions under medical treatment. Because the patient has an ulcer of his duodenum or stomach is no reason why he cannot develop a carcinoma at some other site, and we have two cases which have done so while under observation. First: Male, thirty-seven years of age, who had a duodenal ulcer and had been treated in several hospitals before coming under our care and on admission had a duodenal lesion and after being under treatment for about one year was feeling greatly improved and returned to Poland for a visit of several months. On his return he complained of upper abdominal pain. Reëxamination revealed a carcinoma involving the lesser curvature and at operation the growth was found to be inoperable. There was no relation between the carcinoma in the stomach and the duodenal ulcer from which he had suffered and a careful review of the literature<sup>1</sup> pertaining to duodenal ulcer undergoing carcinomatous degeneration has failed to reveal a definitely proven case of such a complication occurring, although there are any number of primary carcinomas of the duodenum reported.

Another man, forty-two years of age, having had two negative gastro-intestinal X-ray series, was operated upon for an epigastric hernia for the relief of abdominal pain and in June, 1928, three months after the operation, he came under our observation, at which time he had a pyloric ulcer. He did very well under medical treatment and one year later the gastro-intestinal X-ray series revealed the pyloric ulcer healed but another lesion on the lesser curvature at the junction of pars media and pylorica, which was pronounced an ulcer. The patient left town shortly after and was operated upon in another city, due to pain from which he was suffering, and the operating surgeon found what he took to be a carcinoma or a very large indurated ulcer and he did not think a resection advisable, as the growth was fixed, but did a gastroenterostomy. This patient is being followed at the present time and has a definite carcinoma involving his entire lesser curvature. In view of the

history of this patient, it would seem justifiable to assume that when a patient is under treatment for an ulcer of his stomach or duodenum, and the original lesion has responded satisfactorily, and the patient develops a second lesion in the stomach, that we are dealing with a primary carcinoma and not an ulcer, as it has been our experience that gastric ulcers heal much more readily under medical care than duodenal ulcers and therefore it is not logical to assume an ulcer would develop in some other site after the original one has healed and the patient still under treatment.

There have been 110 cases operated upon that are now under observation. Of this number fifty-seven were operated upon for chronic ulcers and most of these previously to 1928, as we have referred only twenty patients for operation during the past three years. Several of these patients are more than ten years post-operative, but we are not attempting to call them cured. In studying the unsatisfactory results we find that most of the cases operated upon early in the disease will not do well regardless of the type of operation, but the cases that have had prolonged medical care, and develop an associated pancreatitis, usually do beautifully following a simple gastroenterostomy. Of the chronic ulcers that we are following, all were not operated upon at Bellevue Hospital but came there for relief of symptoms after having been operated upon in other institutions. There have been forty-seven gastroenterostomies and three partial gastrectomies, six Horsley's and one Finney pyloroplasty. We have had seven marginal ulcers under our observation. One patient, a man twenty-five years of age, was operated upon three months after the onset of abdominal pain and six months after his operation he had a marginal ulcer and within twelve months from the onset of the original pain he had been operated upon a second time when a partial gastrectomy was done for the marginal ulcer and the patient died as a result of same. Another man, thirty-nine years of age, originally had a gastroenterostomy followed by a marginal ulcer. A second operation disconnected the gastroenterostomy. His pain returned and one year later he had a plastic operation for the duodenal ulcer but the pain persisted and two years later he had a second gastroenterostomy and it is now nearly two years since this operation and the patient has been symptom-free. This leaves five cases that had marginal ulcers which are being treated medically and their symptoms had been present from six to eighteen months before starting treatment, and four out of the five patients are greatly improved and practically symptom-free under medical treatment, while the symptoms of one remain unchanged. There are seven patients who have been referred for operation who have had an associated chronic pancreatitis. All of these patients are symptom-free with a simple gastroenterostomy, their follow-up varying from six months to three years. Of the forty-six acute perforations that are being followed in the clinic, most of them are doing quite satisfactorily following a simple closure but four have undergone a second operation for pyloric stenosis, one having to submit to a second operation within ten months, while the longest went five and a half years following the perforation, but it is felt that these patients should

## TREATMENT RESULTS GASTRIC ULCERS

have as little surgery as possible at the time of the original operation. Seven patients have been operated upon for bleeding ulcers. It is interesting to note that one case, a man twenty-five years of age, had a pyloroplasty, two years later a partial gastrectomy and since that has had profuse hæmorrhages, while a second man, fifty-nine years of age, had a profuse gastric hæmorrhage every one or two years over a six-year period, then was operated upon and a gastroenterostomy done. He continued to have hæmorrhages every year for another three years when he was re-operated upon, the second operation being a simple exploratory, finding the gastroenterostomy stoma normal and a duodenal ulcer present and the abdomen was closed without further surgery. Since the second operation, which was three and a half years ago, the patient has not bled. Bleeding ulcers constitute a very difficult group to treat and it is even more difficult to draw conclusions from their study. In a previous paper<sup>2</sup> it was stated that most cases of bleeding ulcers should have transfusions and conservative treatment following the first or second hæmorrhage, but after they have had several recurrent hæmorrhages they should be operated upon as it is known that cases of bleeding ulcers will result in fatalities in spite of transfusions and other supportive measures. Also, some cases will continue to bleed after operation, and this includes every type of operation from pyloroplasties to sub-total gastrectomies.

*Comment.*—From the study of this group of cases one can see that a large percentage of both gastric and duodenal ulcers occurring in patients who seek treatment in a city hospital can be carried along under medical care with very satisfactory results, and if one will refrain from operating upon these patients early in the course of the disease and refer them only after every attempt at medical treatment has failed, the surgical results will be most gratifying with conservative types of operation, either gastroenterostomy or in selected cases of pyloroplasties. Any attempt to call a patient cured after either medical or surgical treatment unless followed for a ten-year period, and frequently examined, is most misleading.

## BIBLIOGRAPHY

<sup>1</sup> Hinton, J. William: Does Carcinoma of the Duodenum Ever Arise from Duodenal Ulcers? *American Journal of the Medical Sciences*. June, 1931.

<sup>2</sup> Hinton, J. William: Bleeding Gastric and Duodenal Ulcers. (Report of fifty-two cases.) *ANNALS OF SURGERY*, April, 1931.

## VOLVULUS OF A SIGMOID MEGACOLON

BY CARNES WEEKS, M.D.  
OF NEW YORK, N. Y.

FROM THE FIRST SURGICAL DIVISION OF BELLEVUE HOSPITAL

VOLVULUS of the sigmoid loop of large intestine is apparently not an uncommon condition. It is described in text-books of diseases of the large bowel and is a well-recognized clinical entity. Volvulus of a giant sigmoid or megacolon, however, appears to be a much rarer condition. A recent experience with the latter type of volvulus and the collection of some sixty-three similar cases in the literature seem to justify the following report:



FIG. 1.—Volvulus of the sigmoid megacolon just before resection and two days after the original exploration.

CASE REPORT.—The patient was an Irish boy of eighteen who was admitted to the First Surgical Division of Bellevue Hospital with a chief complaint of pain in the abdomen of four days' duration. He had not moved his bowels in eight days. The present illness started with a slight pain about the umbilicus which became increasingly severe during the next four days. There was gradually increasing distension of the abdomen. There were slight nausea and vomiting the first day of the illness which returned the day of admission to the hospital. The patient had been unable to move his bowels in the preceding eight days. The administration of large doses of Epsom salts accompanied by numerous enemas failed to relieve this condition.



## SIGMOID MEGACOLON VOLVULUS

There was a past history of constipation since birth, the patient frequently going four to five days without a bowel movement. There had been several mild attacks of abdominal pain when the constipation was more marked than usual, this pain lasting two to three hours. His general health had always been excellent.

On physical examination the patient did not appear acutely ill. The abdomen was moderately distended. There was tenderness to palpation in all four quadrants, most marked about the umbilicus. There was moderate spasm of both rectus muscles. There was no visible peristalsis and no tumor mass could be felt. There was obliteration of

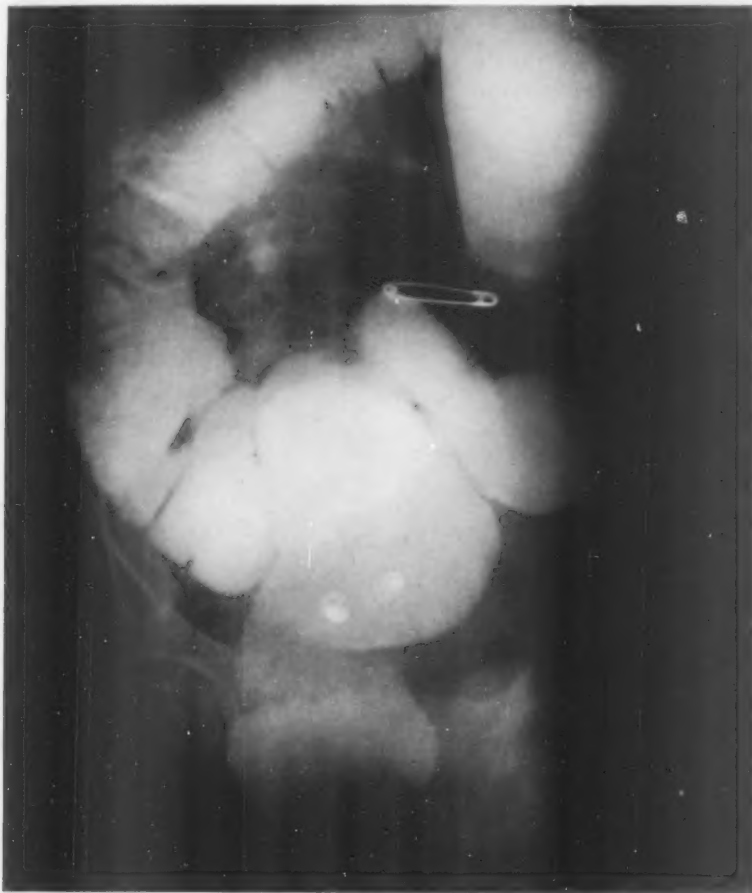


FIG. 2.—Barium enema two months post-operative showing site of anastomosis.

liver dullness. The patient was not vomiting. Temperature 99.6°. Pulse 104. Respirations 24. The white blood count was 9,200 with 84 per cent. polymorphonuclears.

Under a gas, oxygen and ether anaesthetic a right rectus incision was made. There presented in the wound a tremendously dilated structure that at first was thought to be stomach. As this organ almost filled the entire peritoneal cavity, a 20 F. catheter was inserted by means of a purse-string suture and quantities of gas and fecal material escaped. It was then found that we were dealing with a volvulus of an enormously hypertrophied and distended sigmoid loop. It was twisted two and one-half times clockwise about its mesentery. The entire sigmoid was enlarged to about five times its normal size and its wall markedly thickened. This enlargement started at the beginning of the iliac colon and continued down to the recto-sigmoid junction. The rectum was dilated but still con-

## CARNES WEEKS

siderably smaller than the sigmoid. The remainder of the large intestine was distended but did not resemble the pelvic colon in any way. The wall of the involved loop was oedematous, purplish in color but not gangrenous and assumed its normal appearance as soon as the volvulus was relieved. The sigmoid mesocolon was extremely long, very much thickened and oedematous.

The giant sigmoid was then brought out on the abdominal wall and the first stage of a Mickulicz resection was done. The proximal and distal loops were united with interrupted sutures for a distance of three inches below the abdominal wall. By doing this we were able to exteriorize all of the pathologic bowel except that portion of the iliac colon which had no mesentery. The two united limbs were then sutured to the parietal peritoneum at the margins of the wound. The megacolon was then lifted in a direction perpendicular to the patient and an attempt was made to squeeze as much of the blood back into the general circulation as possible. A large tape was then passed

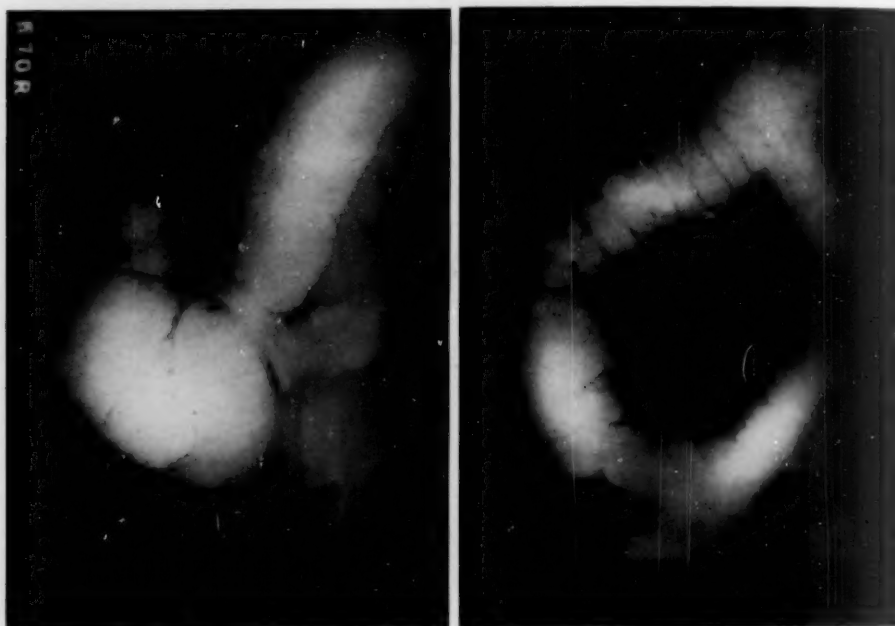


FIG. 3.—A comparison between a barium enema three and one-half months post-operative (left) and that of a normal individual (right).

about the base of the megacolon one inch anterior to the abdominal wall and tied as tight as possible, thus strangulating the loop. A 24 F. catheter was then inserted into the proximal loop to allow for the escape of gas and fecal contents.

The immediate post-operative reaction was excellent. Large amounts of gas and fecal material drained through the catheter.

Two days later the megacolon was resected by means of the actual cautery, level with the abdominal wall (Fig. 1). At this time the very large vessels of the mesentery were tied.

Seven days post-operative a Mickulicz clamp was inserted in the shot-gun barrel openings. Twenty-four days post-operative there was a large opening between the proximal and distal loops. At this time several large masses of impacted feces were removed manually from the rectum. On the forty-second post-operative day the colostomy was closed. At the present time, seven months after operation, the patient is perfectly well and having one normal bowel movement a day. A barium enema two months post-operative shows some enlargement of the bowel above the site of anastomosis and some

## SIGMOID MEGACOLON VOLVULUS

dilatation of the rectum (Fig. 2). A later barium enema, three and one-half months post-operative shows some dilatation still present. Figure 3 is a comparison of the large bowel of the patient with that of a normal individual of the same age. As at operation the large intestine above the iliac colon did not show signs of hypertrophy, we were rather surprised to note the dilatation evident in Figs. 2 and 3. The interpretation of this finding is rather difficult. It is impossible to say whether this patient will eventually develop a true Hirschsprung's disease or whether the dilatation now present is merely a distension of the large bowel and will in time disappear.

*Pathology.*—The specimen (Fig. 4) measures 54 centimetres in length, 25 centimetres



FIG. 4.—The sigmoid megacolon.

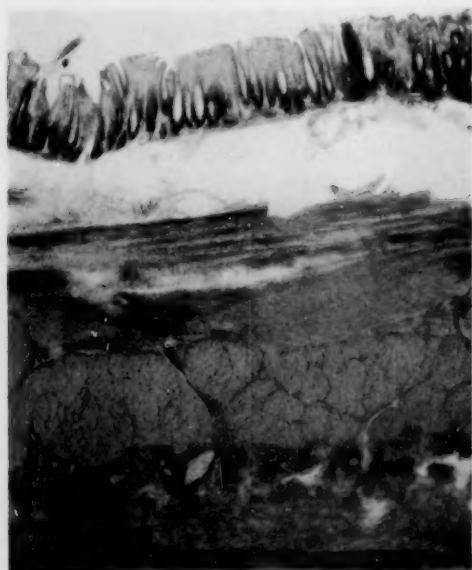
in circumference, and the wall is 10 millimetres in thickness. A comparison (Fig. 5) between a section of the megacolon and a piece of sigmoid from a normal young adult shows the remarkable hypertrophy of all coats, especially the layer of circular muscle. There is a diffuse polymorphonuclear infiltration throughout the entire wall.

TABLE I

Pauchet in 1900 sex—?—13 years old. Operative procedure, detorsion; result, death.
Frommer, A., in 1901 male, 19 years old, 180 degrees of volvulus. Operative procedure, ileo-sigmoidostomy; result, recovery.
Boeckel, J., in 1903 male, 2½ years old, 180 degrees of volvulus. Operative procedure, resection, end-to-end; result, recovery.
Lane, A., in 1904 female. Operative procedure, resection, end-to-end; result, recovery.

## CARNES WEEKS

- Pauchet in 1904 male, 35 years old. Operative procedure, resection, end-to-end; result, death.
- Garre in 1905 male, 28 years old, 180 degrees of volvulus. Operative procedure, detorsion and fixation; result, recovery.
- Bloodgood, J. C., in 1906 male, 65 years old. Operative procedure, resection, side-to-side; result, recovery.
- Tuffier in 1907 male, 60 years old. Operative procedure, colostomy; result, death.
- Feldman, M., in 1908 male. Operative procedure, colostomy; result, death.
- Lecene, P., in 1908 male, 60 years old, 90 degrees of volvulus. Operative procedure, detorsion and fixation; result, recovery.
- Schmieden in 1908 male, 20 years old. Operative procedure, colocostomy; result, recovery.
- Jeannel in 1908 male, 40 years old, 360 degrees of volvulus. Operative procedure, colostomy; result, recovery.
- Bessel-Hagen in 1908 male, 6 years old. Operative procedure, Mickulicz; result, recovery.



Konjetzny, G., in 1910 male, 51 years old, 450 degrees of volvulus. Operative procedure, Mickulicz; result, recovery.

Konjetzny, G., in 1910 male, 24 years old, 180 degrees of volvulus. Operative procedure, Mickulicz; result, recovery.

Konjetzny, G., in 1911 male, 3 years

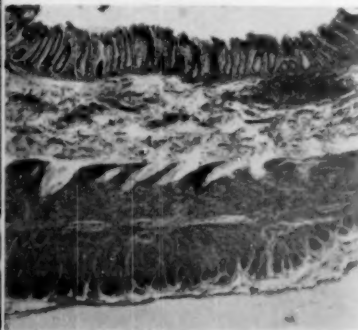


FIG. 5.—Comparison between the walls of the megacolon (left) and of normal sigmoid (right).  
(x 14.)

- old, 180 degrees of volvulus. Operative procedure, resection, end-to-end; result, recovery.
- Clermont in 1911 male, 61 years old, 180 degrees of volvulus. Operative procedure, colocostomy; result, recovery.
- Kraske in 1911 male, 27 years old, 360 degrees of volvulus. Operative procedure, Mickulicz; result, recovery.
- Critchlow, J. F., in 1912 male, 42 years old. Operative procedure, resection, end-to-end; result, death.
- Gregoire, R., in 1912 female, 50 years old, 360 degrees of volvulus. Operative procedure, resection, end-to-side; result, recovery.
- Wideroe, S., in 1912 male, 98 years old, 180 degrees of volvulus. Operative procedure, resection, side-to-side; result, recovery.
- Lecene, P., in 1913 female, 42 years old. Operative procedure, resection, end-to-end; result, death.
- Delbet in 1913 female, 7 years old. Operative procedure, detorsion; result, death.
- Savariaud in 1913 male, 18 years old. Operative procedure, detorsion; result, recovery.

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- Viguiet in 1913 female, 42 years old, 360 degrees of volvulus. Operative procedure, resection, end-to-end; result, recovery.
- Payr, E., in 1916 male, 51 years old. Operative procedure, detorsion and fixation; result, recovery.
- Horhammer in 1917 male, 54 years old. Operative procedure, Mickulicz; result, recovery.
- Rumpel in 1917 male, 42 years old. Operative procedure, resection; result, death.
- Rumpel in 1917 female, 49 years old, 270 degrees of volvulus. Operative procedure, Mickulicz; result, recovery.
- Judd, E. S., in 1917 male, 55 years old. Operative procedure, Mickulicz; result, ?
- Lecene, P., in 1918 male, 76 years old. Operative procedure, detorsion and fixation; result, recovery.
- Nandrot in 1918 male, 31 years old. Operative procedure, Mickulicz; result, recovery.
- Sencert and Simon in 1919 male, 55 years old. Operative procedure, resection, end-to-end; result, ?
- Lecene, P., in 1919 male, 49 years old. Operative procedure, detorsion; result, recovery.
- Luken in 1919 female, 58 years old, 180 degrees of volvulus. Operative procedure, Mickulicz; result, ?
- Payr, E., in 1919 male, 61 years old, 90 degrees of volvulus. Operative procedure, detorsion; result, death.
- Payr, E., in 1919 male, 51 years old, 180 degrees of volvulus. Operative procedure, Mickulicz; result, recovery.
- Rumpel in 1919 female, 40 years old, 270 degrees of volvulus. Operative procedure, Mickulicz; result, recovery.
- Hohlbaum in 1919 male, 29 years old, 180 degrees of volvulus. Operative procedure, Mickulicz; result, death.
- Guimbellot in 1919 female, 26 years old, 630 degrees of volvulus. Operative procedure, resection, end-to-end; result, recovery.
- Schaaning, G., in 1920 male, 45 years old, 360 degrees of volvulus. Operative procedure, resection, end-to-end; result, death.
- Frank, E., 1921 female, 57 years old, 180 degrees of volvulus. Operative procedure, resection, side-to-side; result, recovery.
- Delageniere in 1921 male, 45 years old, 720 degrees of volvulus. Operative procedure, Mickulicz; \* result, death.
- Delageniere in 1921 male, 54 years old. Operative procedure, resection, end-to-end; result, recovery.
- Savariaud in 1921 male, 36 years old. Operative procedure, Mickulicz; \* result, death.
- Miginiac, G., in 1921 male, 46 years old. Operative procedure, Mickulicz; result, death.
- Savariaud in 1921 male. Operative procedure, Mickulicz; \* result, recovery.
- Edwards, S. R., in 1921 female, 47 years old. Operative procedure, resection, side-to-side; result, recovery.
- Edwards, S. R., in 1921 female, 65 years old. Operative procedure, resection, side-to-side; result, recovery.
- Willis, M., in 1922 female, 45 years old. Operative procedure, resection, end-to-end; result, recovery.
- Leflaive, P. G., in 1922 female, 36 years old, 180 degrees of volvulus. Operative procedure, Mickulicz; result, recovery.
- Franke in 1923 male, 78 years old, 180 degrees of volvulus. Operative procedure, resection, side-to-side; result, recovery.
- Roux-Berger, J. L., in 1923 female, 30 years old. Operative procedure, Mickulicz; result, recovery.
- Launay in 1923 female, 50 years old. Operative procedure, resection, end-to-end; result, recovery.
- Launay in 1924 male, 26 years old. Operative procedure, resection, end-to-end; result, recovery.



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- Bonriot in 1924 male, 48 years old, 270 degrees of volvulus. Operative procedure, Mickulicz; result, recovery.
- Hertz, J., in 1924 male, 60 years old, 900 degrees. Operative procedure, Mickulicz; result, recovery.
- Launay in 1925 male, 68 years old. Operative procedure, resection, end-to-end; result, recovery.
- Rochet in 1926 male, 48 years old, 540 degrees of volvulus. Operative procedure, resection; result, death.
- Aumont in 1928 female, 30 years old, 90 degrees of volvulus. Operative procedure, Mickulicz; result, recovery.
- Brocq, P., in 1929 female, 34 years old, 720 degrees of volvulus. Operative procedure, Mickulicz; result, recovery.
- Weeks, C., in 1930 male, 21 years old, 900 degrees of volvulus. Operative procedure, Mickulicz; result, recovery.
- Roux de Brignolles, female, 50 years old. Operative procedure, detorsion and fixation; result, recovery.
- Michon, female, 79 years old. Operative procedure, sigmoidostomy; result, recovery.
- Heller, A., in 1904 male, 45 years old. Operative procedure, autopsy.
- Vene, M., in 1908 male, 72 years old, 90 degrees of volvulus. Operative procedure, autopsy.
- Konjetzny, G., in 1908 male, 4 months old, 180 degrees of volvulus. Operative procedure, autopsy.
- Kleinschmidt, H., in 1910 male, 5 months old, 90 degrees of volvulus. Operative procedure; result, autopsy.
- Konjetzny, G., in 1911 female, 9 months old, 180 degrees of volvulus. Operative procedure, autopsy.
- Wiedhopf, O., in 1913 male, 70 years old, 180 degrees of volvulus. Operative procedure, autopsy.
- Schaaning, G., in 1919 female, 61 years old, 360 degrees of volvulus. Operative procedure, autopsy.
- Belle, D. A. E., in 1920 male, 8 years old. Operative procedure, autopsy.

Table I gives a list and brief résumé of sixty-three cases of volvulus of a sigmoid megacolon collected from the literature, including the author's case, which came to operation. It also includes eight cases in which the volvulus was discovered at autopsy and in which operation was not done. As complete an analysis as was possible has been made from the material submitted by the various authors on the operated cases.

TABLE II

Sex		Age	
Males	42	- 10	4
Females	21	11- 20	4
Not reported	1	21- 30	9
	—	31- 40	7
	64	41- 50	16
		51- 60	12
		61- 70	5
		71- 80	3
		81- 90	0
		91-100	1 (age 98)
		Not reported	3
			64

\* Immediate resection of the volvulus.

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*Sex.*—This condition was twice as common in males as in females. In true Hirschsprung's disease the ratio of men to women is 3 to 2.

*Age.*—There are several points of interest here. Twenty-eight or 46 per cent. of the patients are from forty to sixty years of age, while only 8 or 13 per cent. are under twenty years of age. Mummery in 100 collected cases of megacolon found 30 per cent. under twenty and only 13 per cent. from forty to sixty. This condition of volvulus then appears to occur more frequently in persons past middle life and not so often in children and young people, while exactly the reverse is true in the uncomplicated Hirschsprung's disease.

TABLE III.—Number of cases, 64; constipation, 42; pain, 43; vomiting, 20 (2 fecal); previous attacks, 31; distension, 48; visible peristalsis, 16; mass, 6; positive X-Ray, 3.

*Symptoms.*—Forty-two or 65 per cent. gave a definite history of constipation; fourteen of these from birth, five from childhood and the rest from two to twenty years.

Periods of obstipation, usually associated with the acute attack, were noted by thirty-nine patients. The average duration was four and one-half days; the longest eighteen days. In Hirschsprung's disease it is well known that patients may go many weeks to months without a bowel movement.

Abdominal pain was noted in forty-three cases. Apparently there was nothing characteristic about this pain.

Vomiting was present in twenty; there were two that had fecal vomiting, one recovered and one died.

*Previous Attacks.*—Thirty-one gave a history of one or more previous similar attacks. Bloodgood's patient had thirty-two attacks before the final operation.

Visible peristalsis was present in but sixteen cases and an abdominal mass was felt in six.

In three patients a diagnosis of volvulus was made by means of X-ray.

TABLE IV.—*Previous Operations.*—Number of cases, 15; detorsion, 11; detorsion and colostomy, 5; detorsion and ileostomy, 2; detorsion and appendicostomy, 1; detorsion and colocolostomy, 2; detorsion and ileo-rectostomy, 1; detorsion and fixation, 1; abdominal puncture, 1.

Fifteen patients had twenty-three previous operations for relief of the volvulus, the commonest being simple detorsion. The only attempt to prevent further return of the volvulus was fixation of the sigmoid loop to the parietal peritoneum in one case. Puncture of the abdominal wall with a trocar was done in one case, necessitating immediate exploration for suture of the punctured sigmoid volvulus. This was followed by death due to peritonitis.

*Type of Volvulus.*—(Table I).—In thirty-one cases the volvulus was described; thirteen were 180 or one-half of a turn, two were 90 or two and one-half turns, and the remainder varied between 90 and 900. Fifteen were twisted clock-wise and six counter-clockwise.

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TABLE V.—*Complications*.—Gangrene of involved loop, 8 cases, 5 deaths; peritonitis, 5 cases, 2 deaths; perforation of bowel, 1 case, 1 death; vessels of mesosigmoid (thrombosed), 3 cases, 2 deaths.

TABLE VI.—Number of cases described as megacolon, 64; hypertrophy of all coats mentioned in 18 cases; length of megacolon mentioned in 24 cases; average, 76 centimetres; measurement of normal sigmoid, 40 centimetres; circumference mentioned in 11 cases; average, 35 centimetres; measurement of normal sigmoid, 12 centimetres; diameter mentioned in 15 cases; average, 12 centimetres; measurement of normal sigmoid, 4 centimetres; thickness of wall mentioned in 4 cases; average, 8.7 millimetres; measurement of normal sigmoid, 5 millimetres.

In all of the sixty-four cases the chief finding appeared to be the large size of the sigmoid loop. Unfortunately, exact measurements were not given in twenty-eight cases. In these the authors emphasized the large size of the megacolon by various comparisons; with the large intestine of the horse, the thigh or hip of an adult, *etc.*

TABLE VII.—Dilatation of other portions of the colon, 7; entire large bowel (Hirschsprung's disease), 2; transverse and descending, 2; distal half of transverse and descending, 1; descending, 1; mentioned but not designated, 1. Total, 7.

It is interesting to note that only a little over 1 per cent. of these cases shows involvement of any portion of the remainder of the large bowel and in but two was there evidence of dilatation of the entire large intestine.

TABLE VIII.—*Operative procedure, resection*, Mickulicz, three stage, 18 cases, 2 deaths; resection, end-to-end anastomosis, 15 cases, 4 deaths; resection, side-to-side anastomosis, 6 cases; Mickulicz with immediate resection, 3 cases, 2 deaths; resection, type not mentioned, 2 cases, 2 deaths; detorsion, 5 cases, 3 deaths; detorsion and fixation, 5 cases; detorsion and colocolostomy, 2 cases; detorsion and ileo-sigmoidostomy, 1 case; detorsion and colostomy, 4 cases, 2 deaths. 61 cases, 15 deaths.

Results not known in two cases. Mortality—24.5 per cent. From the above figures and with the experience of the author's case the Mickulicz type of resection in three stages would seem to be the safest procedure.

Whether this condition is congenital or acquired seems difficult to determine. In no one of the sixty-four cases was there any mention made of an obstruction which might have been the cause of the megacolon. There have been many theories put forward as to the possible etiology of this disease and one is that a chronic volvulus due to the long mesosigmoid may eventually cause hypertrophy. But as Mummery says, "Even when such a condition as a chronic volvulus exists this may be a secondary consequence of the dilatation, and not its cause." In his 100 collected cases of this disease he found evidence of obstruction in only twenty-three. In this connection he says, "The fact remains that in the great majority of cases no obstruction of any kind is found and also that in several the dilatation extended right down to the anus or middle of the rectum." That acquired megacolon is a possibility is shown in a recent article by Shelley in which it was possible to follow the development of dilatation of the large bowel subsequent to a stricture of the rectum.

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Whether the disease described in this paper and the so-called idiopathic dilatation of the colon are one and the same we do not know. Recent work by Wade and Royle and by Judd and Adson in connection with lumbar sympathetic ganglionectomy seem to point to a neurogenic origin of the disease in certain of the cases. They believe that the motor impulses to the longitudinal muscle of the rectum are supplied by the parasympathetics, and the motor impulses to the circular muscles of the rectum are supplied by the sympathetics and that the improvement obtained in this disease following ganglionectomy is due to the reduction of the sympathetic stimuli coming from the lumbar rami communicantes through the hypogastric and pelvic plexuses. It will be interesting to follow the course of the patient described in this paper to see whether further enlargement of the remaining large bowel will take place in the future.

### CONCLUSIONS

(1) That there is a very definite clinical entity known as volvulus of a megacolon of the sigmoid.

(2) That the dilatation in this condition is usually limited to the sigmoid in the majority of cases.

(3) That this condition, unlike uncomplicated Hirschsprung's disease, occurs in middle age.

(4) That to prevent further recurrence the involved loop should be resected, preferably by the Mickulicz procedure.

### BIBLIOGRAPHY

- Aumont: Bull. et mém. Soc. nat. de chir., vol. liv, p. 1475, 1928.  
Belle, D. A. E.: (Thèse), Bordeaux, 1921.  
Bessel-Hagen: Quoted by Miginiac, G.  
Bloodgood, J. C.: ANNALS OF SURGERY, vol. xlix, p. 161, 1909.  
Boeckel, J.: Gaz. méd. de Strasbourg, vol. xi, p. 81, 1903.  
Bonniot: Lyon chir., vol. xxii, p. 204, 1925.  
Brocq, P.: Bull. et mém. Soc. nat. de chir., vol. lv, p. 791, 1929.  
Bundschuk, E.: Bruns Beitr. z. klin. chir., vol. lxxxv, p. 58, 1913.  
Clermont: Arch. Méd. de Toulouse, May 15, 1912.  
Critchlow, J. F.: Northwest Med., vol. iv, p. 35, 1912.  
Delageniere: Quoted by Menez, X.  
Delbet: Quoted by Miginiac, G.  
Delkeskamp: München. med. Wchnschr., vol. liii, p. 166, 1906.  
Edwards, S. R.: Indianapolis M. J., vol. xxiv, p. 139, 1921.  
Feldman, M.: Brit. M. J., vol. ii, p. 260, 1908.  
Franke, C.: Deutsche Ztschr. f. chir., vol. clxxxix, p. 89, 1924.  
Frommer, A.: Arch. f. klin. chir., vol. lxxvii, p. 27, 1902.  
Garre: Quoted by Delkeskamp.  
Gregoire, R., and Duval, P.: Bull. et mém. Soc. de chir. de Paris, vol. xxxix, p. 2, 1913.  
Guimbellot: Bull. Soc. de chir. de Paris, vol. xlvi, p. 1456, 1920.  
Heller, A.: Zentralbl. f. chir., vol. xxxv, p. 1446, 1908.  
*Ibid.*: München. med. Wchnschr., vol. lviii, p. 1059, 1911.  
Hertz, J.: Bull. et mém. Soc. nat. de chir., vol. li, p. 494, 1925.  
Hoffmann, G.: Deutsche Ztschr. f. chir., vol. clxi, p. 175, 1921.  
Hohlbaum: Quoted by Hoffmann, G.

# CARNES WEEKS

- Horhammer: Quoted by Hoffmann, G.  
 Jeannel: Arch. méd. de Toulouse, May 15, 1910.  
 Judd, E. S., and Thompson, H. L.: Minnesota Med., vol. xi, p. 439, 1928.  
 Judd, E. S., and Adson: ANNALS OF SURGERY, vol. lxxxviii, p. 479, 1928.  
 Kleinschmidt, H.: Monat. fur Kinderhik., vol. ix, p. 375, 1910-1911.  
 Konjetzny, G.: Beitr. z. klin. chir., vol. lxxiii, p. 155, 1911.  
 Kraske: Quoted by Bundschuh, E.  
 Lane, A.: Med. Press, vol. cxxxviii, p. 503, 1909.  
 Launay: Quoted by Roux-Berger, J. L.  
 Lecene, P.: Rev. de chir., vol. xli, p. 21, 1910.  
*Ibid.*: Quoted by Pichat, E.  
 Leflaive, P. G.: (Thèse), Paris, 1927.  
 Luken: Quoted by Hoffmann, G.  
 Menez, X.: (Thèse vol. xxxiii) p. 16, Paris, 1923.  
 Michon: Quoted by Pichat, E.  
 Miginiac, G.: Arch. d. mal. de l'app. digest., vol. xii, p. 22, 1922.  
 Mummary, J. P. L.: Diseases of the rectum and colon. N. Y. Wood, 1923.  
 Nandrot: Bull. de la Soc. de chir., vol. xv, p. 676, 1919.  
 Pauchet, V.: Arch. prov. de chir., vol. xxii, p. 17, 1913.  
 Payr, E.: Quoted by Hoffmann, G.  
 Pichat, E.: (Thèse vol. clxxxviii) Paris, 1928.  
 Rochet, P.: Lyon chir., vol. xxiv, p. 77, 1927.  
 Roux-Berger, J. L.: Bull et mém. Soc. nat. de chir., vol. li, p. 418, 1925.  
 Rumpel: Quoted by Hoffmann, G.  
 Savariaud: Quoted by Miginiac, G.  
 Schaaning, G.: Norsk Mag. f. Laegevid., vol. lxxxi, p. 804, 1920.  
 Schmieden: Deut. Med. Woch., vol. xxxiv, p. 1747, 1908.  
 Sencert and Simon: Quoted by Pichat, E.  
 Shelley, H. J.: ANNALS OF SURGERY, vol. xciii, p. 910, 1931.  
 Tuffier: Bull. de la Soc. de chir., vol. xxxiv, p. 1068, 1907.  
 Verse, M.: München. Med. Wchnschr., vol. lvi, p. 654, 1909.  
 Viguiet: Quoted by Miginiac, G.  
 Wade and Royle: M. J. Australia, vol. i, p. 137, 1927.  
 Wideroe, S.: Norsk Mag. f. Laegevid., 5. R., vol. xx, p. 1344, 1912.  
 Wiedhopf, O.: München. med. Wchnschr., vol. lxi, p. 2238, 1914.  
 Willis, M.: Virginia M. Month., vol. xlviii, p. 651, 1921-22.



## DIVERTICULUM OF THE MALE URINARY BLADDER

By J. CHRISTOPHER O'DAY, M.D.

HONOLULU, HAWAII

THE initial cause of sacculated or diverticulated bladders is, perhaps with some few exceptions, congenital; traceable to some embryologic disparity; a disparity so likely to be compromised by any degree of deformity from a mere sacculation to the most pronounced exstrophy—even hypospadia and anaspadias, that the resulting problems have, on many occasions, tried and baffled the judgment of the most adroit of genito-urinary surgeons.

Obstruction, whether partial or complete, has, by many observers, been regarded as an important etiologic factor, yet, and while it must be admitted that such an obstruction to the bladder's outlet is a cause in the bringing forth of this deformity, it must not be forgotten that it is merely a relative one. Nor should it prevent the fullest inquiry when it must be ever in mind that the question of a ratio is ever present—the ratio that correlates that great number of occluded urethrae where diverticula or saccule do not obtain, and the much smaller number where they do. Here, may the question of "why?" be interjected. Why are saccule and diverticula the exception, then, instead of the rule when this comparison is made to parallel these two sets of reckonings?

There are those of our genito-urinary surgeons who, having felt the truth of this, concluded that urethral obstructions, whether of prostatic or cicatricial origin, are mere factors. Never a cause.

The normal bladder may be distended to a remarkable degree without entailing the slightest risk of provoking either saccules or diverticula. Let it be put in this way, namely: The actual cause of sacculation or diverticulation within the wall of the male urinary bladder is congenital but is impotent unless urethral obstruction, partial or complete, distention and compression be present as contributing factors.

To determine how much of the truth might be coupled with the foregoing supposition, a number of bladders, secured from slaughtered pigs, were subjected to the following rather crude tests. When extreme distention was induced by either water or air, the mucosa, at no point, showed a tendency to herniate. Nor did it when severe compression was subsequently applied. But when a portion of the bladder's wall had been gently teased away from its underlying mucous lining, and the maneuver repeated, no sign of pouting appeared until the compression was applied, and then, and almost immediately, the mucosa began to bulge through the denuded area, and a diverticulum, in the making, was emphatically demonstrated.

There are those among our physiologists who teach that the normal act of urinating depends more on compression from the intestines than it does on the

contractility of the bladder's muscular coat. If this is true, the fact that the bladder has a muscular coat, moots the question. However, that cannot be discussed here. But whatever the truth of it may be, compression, up to some unknown degree, seems to be the determining factor in forcing the mucous membrane to herniate into an extravescical sac. It must not, however, be forgotten that unless ectopia of the muscular fasciculi be present, neither the obstruction, distention nor compression can give rise to the deformity.

To elucidate the primary or congenital cause of these diverticula, it will

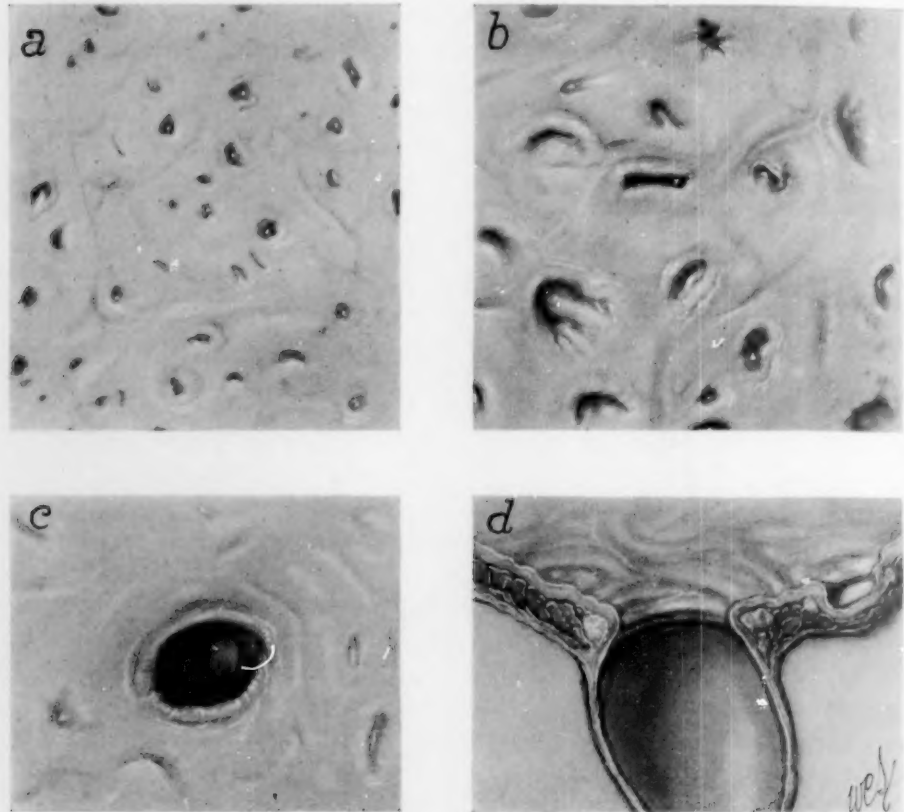


FIG. 1.—(a) Small sacculations; the fasciculi are not displaced to a degree capable of pouting the bladder's mucosa into a diverticulum. (b) Large sacculations. Here are the openings that lead to a sac only. Diverticulitis is not to be expected where so many large sacculations are present. It may occur, but the fasciculi are usually discouragingly arranged. (c) Typical opening into diverticulum. Note the fibrous ring. (d) Section of diverticulum.

be necessary to briefly review the embryologic development of the genito-urinary tract. In doing this, we will find something to puzzle over when, through speculative curiosity, we would like to find out the time that the kidneys begin the first secretion of urine.

Of course, this question is irrelevant. Perhaps it should have been omitted, yet it is an emphasis on that which is of paramount interest, for it becomes apparent that unless the allantois had opened into the ventral cloaca in time to save itself from becoming distended by the urine from the newly functioning

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kidneys, a disparity of that portion of its structure, destined to be the muscular coat of the developing bladder, would result in a chaotic dispersion of the subsequently developed muscular fasciculi, and thus force into the bladder wall areas of potential diverticula. If the allantois is granted its communication with the ventral cloaca before the distention has caused an irreparable condition, no more than an illy marked trabeculation may be the ultimate result. Otherwise, should some embryologic irregularity prevent a timely communication, and the distention finally end in rupture, an exstrophy would be the likely result. Between these two extremes, may be conjectured the various congenital bladders with which we have to deal, and in which is to be found the reasons why the best of us are often at our wits' end, for we are dealing with defects that are not always amenable to good surgery because of the flabbiness of the tissues with which the repair has to be made; a flabbiness that had its origin in or during the embryologic distention. Pouching of the bladder wall is a condition that in no way should have its etiology confused with that of the diverticula or sacculation. Pouching may come to any normally developed bladder through the presence of a calculus, the removal of which, followed by proper drainage, is all that is required to restore the pouched portion of the bladder's wall to its normal contour.

Experience has given us a fear of sodium bromide when used as a diagnostic adjunct to röntgenology. It was the only medium used through which we had two severely fatal burns. I know of no statistics on this particular point, but having had no such sequela following the use of the milder salts of silver, we had given up the bromide salt entirely. When possible, the cystoscope is the diagnostic instrument of choice rather than the X-ray.

What has been outlined in the foregoing is meant as a mere sketch of the conditions through which all surgical approach has to be made. In a word, it gives to us the key to the greatest success attainable, for it emphasizes the importance of restoring to the urethra the fullest patency, even to the removal of the prostate when its urethral tunnel is found to be narrowed, and this without regard to the size of the gland itself.

Immediate surgery in all these cases is, as a rule, contraindicated. Suprapubic drainage must be the prerequisite of all that is hoped to be accomplished. It also gives immediate relief to the distressing tenesmus-vesicæ. While this drainage is going on, the urethra may be sounded and rendered patent. If its prostatic portion is found to be menacingly narrow, prostatectomy is to be postponed until the bladder has been suprapubically opened for the removal of the diverticulum. Not a few methods of coping, surgically, with bladder diverticula have been described. It probably matters but little what method may be the one of choice so long as good results are obtained, but the method that calls for the sac's inversion, in our experience, proved too cumbersome. It also sacrifices tissues that will be greatly needed in obliterating the space that the sac had previously occupied. Stuffing the diverticulum with gauze lacks surgical appeal because of the danger of tearing the bladder wall while delivering the sac. The opening into these sacs is encircled with a fibrous

ring. This ring must be removed else union will be thwarted. The incision should be an elliptical one, its long axes directed to the securing of the best working facilities. It includes the entire fibrous ring with the mouth and end of the sac. With this accomplished, the freed portion is grasped with light forceps and gentle traction is continued into the bladder while a gauze-capped finger gently pushes back whatever tissue may be adherent. If the opening thus made in the wall of the bladder is large enough to admit a finger without the likelihood of tearing, the fibrous ring may be severed by a snip

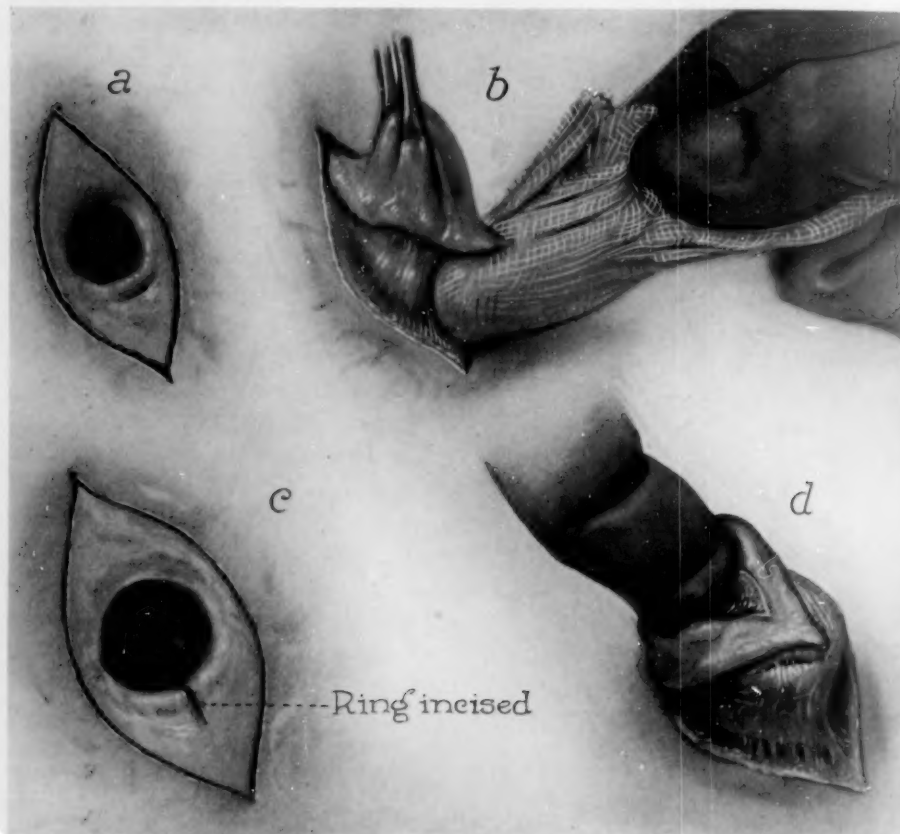


FIG. 2.—(a) Elliptical incision preliminary to dissection of the diverticulum. (b) Ellipse with opening into sac being drawn into bladder while a gauze-capped finger pushes back all adhering tissue. (c) Ring incised to admit finger. (d) Once the sac is made free a finger within facilitates the dissecting.

of the scissors and the further dissecting of the sac facilitated by inserting a finger within it. Throughout the time it may require to complete the removal of the sac and the subsequent closure of the opening, sopping with sponges will take care of the urine that is coming in from the ureters.

The ease with which the water-shed closure of the opening may be effected will, of course, depend very much upon what portion of the bladder wall is involved. If high, and easily reached from the suprapubic incision, little difficulty need be expected. When, however, it is low, and the diverticulum

## DIVERTICULUM URINARY BLADDER

has been in a posterior position, the closure should be effected from within the bladder, for extensive separation from surrounding tissues is liable to invite sloughing. The method we have followed is not difficult, yet, it may, at the first try, seem so. Number O O chromic gut is the ideal suture material, but it should be softened and rendered pliable in warm water, and by gauze-friction before using. Otherwise it will be too harsh. For the suturing, a small, full-curved, non-cutting intestinal needle is ideal. The stitch may be begun at either angle of the ellipse according to the convenience of the operator. Inverting the edges of the wound, the needle is made to pick up, right side first, two or more bites of the inverted edge, working the needle away from the free edge while doing so. It is then passed across to the left side of the incision and the maneuver repeated with the exception

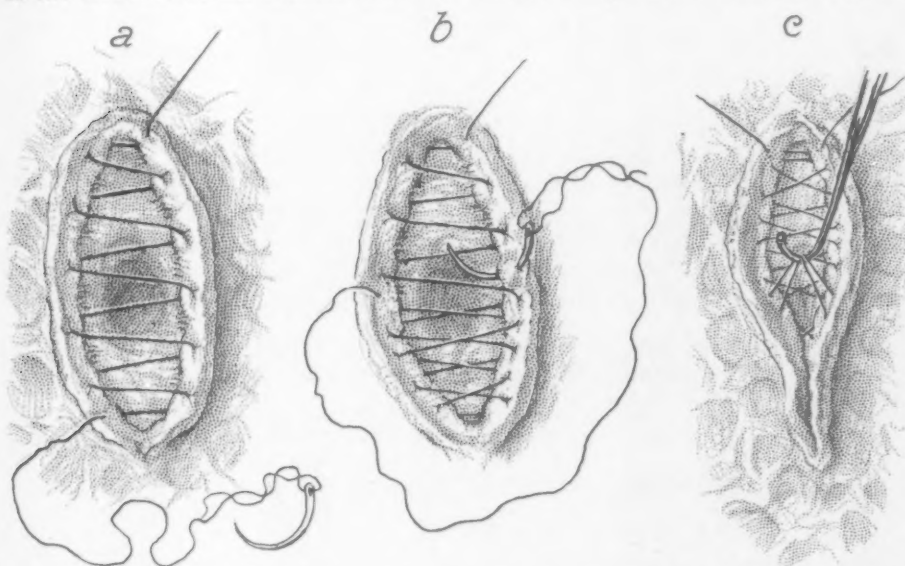


FIG. 3.—*a*, *b*, and *c* shows technic of a modification of Murphy's (the late John B.) water-shed suture. This stitch closes the bladder wound without appearing within the viscus. This avoids leaving any foreign substance to precipitate crystallization of the urinary salts.

that on this side the needle is made to work toward the free edge. The suture from this point on is zigzagged toward the opposite angle which, when reached, is given a horizontal direction as in the first application, then zigzagging back, crossing the others to make a series of X's, similar to the lacing of a shoe, until the place of beginning has been reached. The two free ends of the suture are permitted to protrude from between the edges of the wound while a pterygium hook draws the lacing taut. Finally, traction on the ends will approximate the edges in to an appositional or water-shed welt.

The suture may then be tied, the ends cut, and the knot induced between the edges and forced into an extravescical position.



## EXTIRPATION OF PREGNANT UTERUS AT FULL TERM \*

BY WILLIAM WERTENBAKER, M.D.

OF WILMINGTON, DEL.

FROM THE DEPARTMENT OF GYNECOLOGY AND OBSTETRICS OF THE WILMINGTON GENERAL HOSPITAL

ABOUT March 1, 1928, Dr. M. A. Tarumianz, of the Delaware State Hospital for the Insane, at Farnhurst, referred to me a Negress, aged thirty-three years, the subject of general paresis. She was the mother of six children, only two living and both mentally deficient; she was at that time within ten days of term with another pregnancy; her Wassermann was four plus, there was a profuse cervical discharge which showed numerous gonococci. To further complicate the situation, the foetal breech was lying in the right iliac fossa. The indications called for (1) Avoidance of the spread of gonorrhoeal infection; (2) sterilization of the mother; and (3) delivery of the foetus. To accomplish these triple ends I decided to remove the entire uterus before rupture of the membranes.

On March 15, 1928, the abdomen was incised in the lower mid-line, the broad ligaments clamped on each side and incised down to the level of the cervix. Two clamps, sufficiently long to reach across the entire cervical bridge, were thrown into place and the uterus delivered from the abdomen. The cervix was severed with a single cut between the two clamps; the uterus, with its contents, was passed to an assistant, Doctor Pawlikowski, who extracted a living foetus weighing seven pounds, two ounces. The time consumed from start of abdominal incision to delivery of child was less than four minutes.

The cervical stump was cauterized and turned in with a running suture, the stumps of the round and infundibulo-pelvic ligaments ligated, brought down and sutured to it. A fold of the utero-vesical peritoneum was then brought over all to complete the peritoneal toilet. One cigarette drain was placed in the cul-de-sac and the abdomen closed in three layers.

This woman made an uneventful surgical recovery.

Since that time I have met with five other cases in which it was felt wise to adopt a similar line of procedure. Two were cases in whom one or more previous Cæsarean sections had previously been made, in whom numerous pelvic and abdominal adhesions were doubtless present; one a case of marked hyperthyroidism with uterine fibroids; another a woman exsanguinated by hæmorrhage due to placenta previa, in which case a minimum of blood loss at delivery was felt essential to give her any chance, which she might possibly have, of recovery.

These cases were operated upon respectively on July 19, 1930; December 20, 1930; January 12, 1931; February 18, 1931; April 3, 1931. All six babies were delivered alive; five mothers made uneventful recoveries and left the hospital in good condition. One mother (Case II) developed a vesico-abdominal fistula on the ninth day, which was closed at a subsequent operation.

In Case IV violent uterine contractions began as soon as an attempt to deliver the uterus from the abdomen was made, and the membranes ruptured just as this was accomplished; so, after the "waters" had drained away, a

\* Read before the Kent County Medical Society, Dover, Delaware, April 1, 1931.

## EXTIRPATION OF PREGNANT UTERUS

clamp was placed across the cervix, the latter incised above it, and the foetus delivered before entire extirpation of the uterus.

When conservation of the tubes and ovaries is desired, the operation is more difficult, as the uterine extremities of the broad ligaments are pulled upward by the enlarged organ and offer a much wider pedicle to be clamped and ligated.

The use of this operation is suggested for those cases where classical Cæsarean section would be followed by hysterectomy (the Porro operation and its modifications):

(1) Where it is of primary and vital importance to avoid contamination of the abdomen.

(2) Where it is deemed best to avoid subsequent pregnancies in the patient.

(3) Where extirpation of the uterus would be otherwise indicated, as in co-existing fibroid tumors (Case IV).

(4) Where it is imperative to obviate all possible blood loss.

The operation is not indicated where it is desired and feasible to continue the reproductive function of the woman.

The average time of the operation has been shorter than the average time of classical Cæsarean section; the "shock" less, or certainly no greater; and a less complicated convalescence is usual.

This method is offered, *not as a substitute for other methods of Cæsarean section* (save the Porro operation), but as a contribution to the armamentarium of the obstetrician, to be held in reserve until the emergency to which it is applicable arises.

### ABSTRACT OF CASES

CASE I.—Chester, Pa. Age, thirty-three years, Para VII. Referred by Dr. M. A. Tarumianz.

Term pregnancy. Oblique position of foetus. Lues. Gonorrhœal cervicitis. General paresis.

*Operation.*—March 15, 1928. Anæsthesia.—Ether.

*Infant.*—Male; condition good; weight 7 pounds, 2 ounces. N. B.—Turned over to Children's Bureau on March 17, 1928, apparently in good condition.

*Surgical Convalescence.*—Uncomplicated.

CASE II.—Penn's Grove, N. J. Age, twenty-one years, Para III. Referred by Dr. R. B. Jarrett.

Pregnancy at thirty-sixth week. Two previous Cæsarean sections (1926 and 1928). Weakening uterine cicatrix. Pelvic adhesions.

*Operation.*—July 19, 1930. Anæsthesia.—Gas-ether.

*Infant.*—Female; fair condition upon delivery; weight 6 pounds, 2 ounces. N. B.—This infant died nine hours after delivery. *Autopsy.*—Interstitial pneumonia; hyperplastic thymus; cloudy swelling of the kidneys.

*Surgical Convalescence.*—Complicated by development of an abdomino-vesical fistula on the eighth day. Apparent spontaneous closure after ten days' use of a self-retaining catheter. Mother discharged in good condition on August 16, 1930. Returned to hospital August 26, 1930, after reopening of fistula. Surgical closure under gas anæsthesia on August 27, 1930. Final discharge on September 13, 1930, in good condition.

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CASE III.—Millington, Md. Age, twenty-seven years, Para V. Referred by Doctor Brice.

Pregnancy at thirtieth week. Free uterine hæmorrhage. Full placenta previa.

*Operation.*—December 20, 1930. Anæsthesia.—Gas (only).

*Infant.*—Male; living but premature; weight not recorded. N. B.—This infant died in sixty-two hours. *Autopsy.*—Patent foramen ovale. Prematurity.

*Surgical Convalescence.*—Uncomplicated. Mother discharged in good condition on January 4, 1931—fifteenth day.

CASE IV.—Wilmington, Del. Age, thirty-five years, Para I. Referred by Dr. B. J. McEntee.

Hyperthyroidism. Uterine fibroids. Term pregnancy.

*Operation.*—January 8, 1931. Anæsthesia.—Gas (only).

*Infant.*—Female; condition good; weight 6 pounds, 12½ ounces.

*Surgical Convalescence.*—Uncomplicated. Discharged in good condition on sixteenth day.

CASE V.—New Castle, Del. Age, twenty-nine years, Para II. Referred by Dr. Lewis Booker.

Term pregnancy. Contracted pelvis. Previous Cæsarean section. Pelvic adhesions.

*Operation.*—February 18, 1931. Anæsthesia.—Spinal.

*Infant.*—Female; condition good; weight 8 pounds, 8 ounces.

*Surgical Convalescence.*—Uncomplicated. Discharged on seventeenth day in good condition.

CASE VI.—Wilmington, Del. Age, twenty-nine years, Para III. Referred by Dr. Fred Armstrong.

Term pregnancy. Contracted pelvis. Two previous Cæsareans.

*Operation.*—April 3, 1931. Anæsthesia.—Spinal.

*Infant.*—Female; condition good; weight 6 pounds, 1½ ounces.

*Surgical Convalescence.*—Uncomplicated. Discharged on fourteenth day in good condition.

*Comments.*—At the time the first operation was performed no thought of attempting a new procedure was entertained. It was approached entirely with the idea of working out what was best for the particular case. However, as other cases were brought to us to which the same principles could be advantageously applied, variations were tried and discarded or adopted, oftener the former.

In Case I Doctor Tarumianz desired the removal of the ovaries for psychiatric reasons, so the infundibulo-pelvic, round and broad ligaments were clamped and cut distal to the tubes and ovaries. In the same case only so much of the utero-vesical peritoneum was reflected as would serve as a flap for the cervical stump.

In subsequent cases it was found that the former was easier than where it was desired to conserve the ovaries and tubes, but, on the other hand, that the reflection of the utero-vesical peritoneum and bladder not only gave a neater result but otherwise expedited the operation.

In Case IV delivery of the uterus from the abdomen was done before reflection of the utero-vesical peritoneum and severing of the broad ligaments. This was found a distinct handicap rather than an advantage.

The use of gauze sponges, or pads, was discarded until after delivery of

## EXTIRPATION OF PREGNANT UTERUS

the uterus, as they are not needed and interfere with motility of the intra-peritoneal structures.

Adhesions which may exist from previous operations or other causes, should be carefully and completely freed as the first step after entering the abdomen.

The results of our work, so far, have led to the adoption of the steps as outlined below, and in the order given:

- (1) Incision of abdomen.
- (2) Freeing of adhesions, if existent.
- (3) Reflection of the utero-vesical peritoneum and bladder.
- (4) Application of clamps to broad ligaments.
- (5) Severing of broad ligaments.
- (6) Delivery of uterus from abdomen.
- (7) Application of clamps to cervix.
- (8) Severing of cervix.
- (9) Passage of uterus and contents to assistant (who immediately extracts infant).
- (10) Ligation of broad ligaments.
- (11) Suture of cervical stump.
- (12) Suture of pedicles to cervical stump.
- (13) Suture of utero-vesical peritoneum over "raw" area.
- (14) Drainage of cul-de-sac, at discretion of operator.
- (15) Closure of abdominal incision.

## INTERPARIETAL HERNIAS

By WILLIAM E. LOWER, M.D., AND N. FRED HICKEN, M.D.

OF CLEVELAND, OHIO

FROM THE CLEVELAND CLINIC

THE term "interparietal hernia" is used collectively to designate a group of rather unusual hernias which are located in the inguinal region between the various layers of the abdominal parietes. Anatomically, these hernias may be classified as follows: (1) Properitoneal hernia, that type in which the hernial sac lies between the peritoneum and the transversalis fascia; (2) interstitial hernia, in which the sac lies between the transversalis fascia and the transversalis, internal oblique, or external oblique muscles; and (3) superficial hernia, in which the sac is situated between the aponeurosis of the external oblique muscle and the integument.

Since interparietal hernia has been spoken of by all authorities as being of rare occurrence it is surprising to find that 587 cases have been reported in the literature. The inability to diagnose this condition pre-operatively and the consequent high mortality rate indicate how superficial is our knowledge of this type of hernia. Since the days of Thomas Bartholin (1661), many noted surgeons have been chagrined because they failed to recognize this type of hernia at the operating table, the mistake being revealed at necropsy.

Because of these considerations, we feel justified in presenting a clinical study of interparietal hernias based on cases observed at the Cleveland Clinic and those reported in the literature.

### TWO CASES OF INTERSTITIAL HERNIA

CASE I.—The patient, a truck driver, aged fifty-eight, reported at the Cleveland Clinic April 27, 1920, complaining of pain occurring low in the left side.

Four years previously, a severe pain suddenly developed in the lower left abdominal quadrant radiating downward toward the bladder and penis. The paroxysm lasted about thirty minutes and then subsided, leaving him perfectly well. There had been no nocturia, frequency, burning on urination, urgency, nor hematuria, and the urine had never contained any gravel.

Three months later a similar attack occurred, and since then the attacks had progressively increased in frequency and severity. Most of the paroxysms were initiated by work, exercise, lifting, or straining, and were always associated with the act of defecation. When the patient lay down, the pain immediately disappeared, often recurring, however, as soon as he stood up. He had never observed any swelling in the groin, and emphatically denied being "ruptured." Both testicles had always been in the scrotum. The day before his admission to the clinic he had an attack of severe pain in the left groin and felt nauseated but did not vomit. The pain was intense while he was working, but subsided when he assumed a recumbent position. Some soreness was present in the region of the left groin.

The general physical examination showed a well-nourished adult male. The temperature was 97.6°, the pulse rate 64, and the blood-pressure 135/100. The pupillary



## INTERPARIETAL HERNIAS

reactions were normal, the teeth were in good condition, the tonsils atrophic, and the heart and lungs were normal. The abdomen was symmetrical, slightly distended, and presented the appearance of generalized rigidity. The patient complained of slight tenderness in the left groin above Poupart's ligament near the internal inguinal ring, and when pressure was applied at this point the patient felt a sense of soreness and said that he could feel "something slipping back into the abdomen." No masses or swellings could be detected. Both external rings were slightly dilated, but no hernial sac could be felt, and no impulse was transmitted during the act of coughing. Cystoscopic and pyelographic studies showed that the genito-urinary tract was normal, and all laboratory studies gave normal values. Gastro-intestinal roöntgenograms failed to indicate any point of intestinal obstruction.

We felt that we were dealing with a case of partial intestinal obstruction produced by some mechanical constriction in the region of the internal inguinal ring. We were convinced, however, that the cause was not a common direct or indirect inguinal hernia. As conservative treatment did not result in improvement, operative intervention was deemed necessary.

An oblique incision was made in the lower left quadrant a half-inch above and parallel to Poupart's ligament. The aponeurosis of the external oblique muscle was exposed, but no inguinal hernia was palpable. On palpation in the region of the internal inguinal ring, a "gurgling sensation" could be felt, and it seemed as if a "loop of bowel" suddenly receded into the abdomen. The external oblique muscle was incised just mesial to the course of the inguinal canal, and a small empty hernial sac was found between the external and internal oblique muscles. By careful dissection the sac was isolated and it was found to have passed through the internal and external oblique and transversalis muscles, piercing the transversalis fascia, and opening into the peritoneal cavity about 1 centimeter to the left and just above the internal inguinal ring. There was no communication with the inguinal canal. The spermatic cord and vessels could be seen entering the inguinal canal through the internal ring, and no inguinal hernia was demonstrable. The orifice of the hernial sac readily admitted the thumb, and the neck was thick and elastic but easily dilatable. The belief seemed reasonable that any increased intra-abdominal pressure would dilate the neck of the sac and permit the intestines to enter. No incarceration, however, had taken place. The neck of the sac was securely ligated, the various layers of the abdominal wall were closed, and the patient made an uneventful recovery.

CASE II.—The patient, a woman, aged forty-one, the mother of three children, reported at the Cleveland Clinic on May 13, 1930, complaining of abdominal pain.

For the past six years she had suffered from flatulence, abdominal distention, and pains in the upper right quadrant. On two occasions there had been "chills and fever," associated with some tenderness over the region of the gall-bladder. Five years before this examination cholecystostomy had been performed, and a few stones and much pus had been found. Since then abdominal pain and tenderness had recurred in the old scar. During the three months previous to her entering the Clinic, pain had been present in the right inguinal region which was accentuated by working or by lifting heavy objects. At times the patient thought she could feel a slight swelling in the groin, but when questioned, she admitted that it was only her "imagination." At times the distress became so intense that she would be compelled to lie down, and immediately she would feel a peculiar "sliding sensation" in the right groin, and the pain would disappear. She denied having been ruptured.

Examination revealed a well-developed adult female. The temperature was 99.2°, the pulse rate 92, and the blood-pressure 148/94. The pupils were equal, with normal reactions. The heart and lungs were essentially normal. A scar in the upper right rectus muscle was indurated, tender, and inflamed. There was some localized muscular

## LOWER AND HICKEN

rigidity but no feeling of fluctuation. The gall-bladder could not be palpated on account of the tenderness in this region. In the right groin, just above the external inguinal ring, was a small swelling which increased in size on straining and to which a definite impulse was imparted by coughing. The external ring was small, and no enterocele could be palpated in the canal. Both femoral rings and the left external inguinal ring were normal.

The pre-operative impression was that an abscess of the gall-bladder was pointing in the old cholecystostomy scar, and that an interstitial hernia was present in the right inguinal region. The latter diagnosis was made because of our experience with the previous case.

A transverse incision was made over the right inguinal canal. A probe was readily introduced into the canal through the external ring, and no enterocele or obstruction was encountered. On palpation, a small tumor-like mass could be felt just near the outer side of the canal. An incision was made directly over the swelling, and as soon as the fibres of the external oblique muscle were separated, a small, partially collapsed hernial sac was seen lying between the two oblique muscles. When this sac was opened, a few tags of omentum were disclosed. The sac was carefully dissected free from the adjacent structures, to which it was fairly adherent. It lay in direct apposition to the lateral walls of the inguinal canal, pierced the internal oblique and transversalis muscles, as well as the transversalis fascia, and opened into the peritoneal cavity by its individual orifice, situated just lateral to and above the internal inguinal ring. The round ligament entered the inguinal canal through a normally located inguinal ring, and there was no communication between this canal and the interstitial hernia. The sac was ligated, the aperture through the abdominal wall was closed, and the patient made an uneventful recovery.

In both of the cases described above the condition was caused by a simple interstitial hernia, the sac in each instance being contiguous to but not communicating with the inguinal canal, each having its own separate orifice. Krönlein has discussed this type of hernia to which, because of its juxtaposition to the inguinal canal, he gave the name "para-inguinal interstitial hernia."

As there are three anatomical varieties of interparietal hernia—properitoneal, interstitial and superficial hernias, these will be discussed separately.

### PROPERITONEAL HERNIA

The first authentic report on interparietal hernias was made by Bartholin in 1661, but his description was not sufficiently complete to permit classification. In 1779 Petit described a group of hernias which were situated within the interstices of the abdominal wall. In 1839 Parise saw a hernia in which the sac was situated between the peritoneum and the transversalis fascia, and in 1851 he described it under the name of "intra-iliac hernia." In 1864 Streubel collected reports of fourteen cases. The most important work however was done by Krönlein, a report of which was published in 1876. He collected and analyzed twenty-three cases which had been reported up to that time; he carefully described the anatomical positions and clarified the etiologic factors concerned in their production, giving to this type of hernia the name "hernia inguinoproperitonealis." In 1895 Breiter, a pupil of Krönlein, collected thirty-six additional cases, and in 1900 Göbell brought the literature up to date, presenting a series of sixty-nine cases. Since that time

## INTERPARIETAL HERNIAS

we have been able to gather reports of fifty cases from foreign and English journals, making a grand total of 119 cases of properitoneal hernia thus far reported.

*Definition and Anatomical Considerations.*—Since properitoneal hernia usually occurs in the form of a diverticulum from the walls of an inguinal or femoral hernia, cases of this type are generally designated inguinoproperitoneal or cruroproperitoneal hernias. Moynihan reserves the name "properitoneal hernia" for those which fulfill the following conditions: (1) The hernial sac must be bilocular, one locus extending down into the inguinal or femoral canal, and the other spreading out between the peritoneum and the transversalis fascia. (2) The two loculi must communicate with each other. (3) Both loculi must open into the peritoneal cavity by means of a common orifice—either the internal inguinal or the femoral ring.

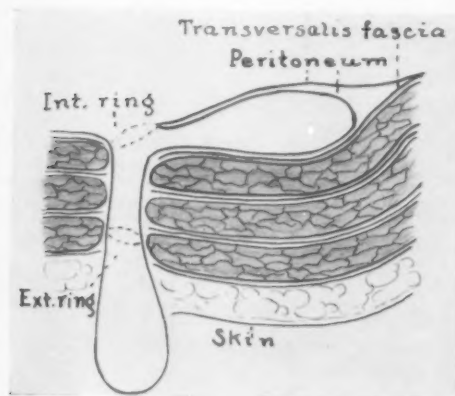


FIG. 1.—Bilocular properitoneal hernia.

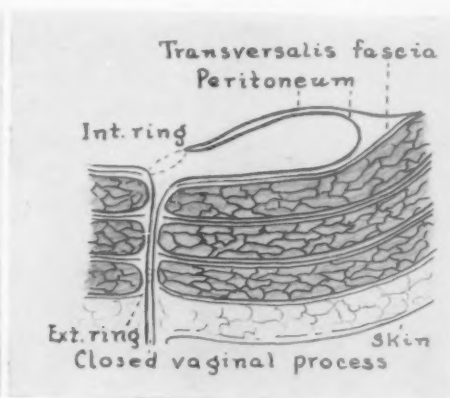


FIG. 2.—Monolocular properitoneal hernia.

Moynihan, Halstead, and many other authorities agree that all properitoneal hernias are bilocular, as shown in Fig. 1. However, we have been able to collect fourteen authentic cases in which only one sac could be demonstrated, as illustrated in Fig. 2. At operation, the enterocele was found to have entered the inguinal canal through a normal internal inguinal ring, but instead of extending down the inguinal canal, the hernial sac had spread out between the fibres of the peritoneum and transversalis fascia. The process vaginalis which continued down into the scrotum or into the labia was completely closed, and no hernia was present. These, therefore, were typical monolocular hernias. Göbell found that of sixty-nine cases of properitoneal hernia sixty were bilocular and nine were monolocular. Novaro, who in 1921 made a careful study of this type of hernia, is convinced that monolocular forms do exist.

Halstead maintains that a properitoneal hernia always occurs as a diverticulum or outpouching from a preëxisting inguinal or femoral hernia. However, the following cases suggest that a properitoneal hernia can occur as a distinct and separate entity, without having any communication with the inguinal or femoral canals. Wagner, Brunner, and Englisch each report a

case of an inguinal hernia and a coëxisting properitoneal hernia. These hernias were separate and distinct, each opening into the abdominal cavity through an individual orifice. In 1902, Howlett reported a case of a bilocular properitoneal hernia in which both loculi were situated between the peritoneum and transversalis fascia, one sac extending upward and outward and the other downward and inward. At the first operation only one sac was recognized, but as the symptoms of nausea and vomiting persisted, a second operation was performed which revealed a loop of strangulated bowel in the second properitoneal sac. This is a good example of a properitoneal hernia occurring outside of the inguinal canal but lying adjacent to it.

It would seem, therefore, that properitoneal hernia, in both the monolocular and the bilocular forms, may be classified as follows: (1) Inguinoproperitoneal hernia, which occurs as a diverticulum from a preëxisting inguinal hernia. (2) Cruroproperitoneal hernia, which occurs as an outpouching of a femoral hernia. (3) Simple properitoneal hernia which is independent of the inguinal or femoral canals.

The anatomical positions which may be assumed by the properitoneal sac must be clearly understood if these hernias are to be treated surgically. Usually it occupies one of three positions: (1) It may pass upward and outward toward the anterosuperior iliac spine. This is the usual position. (2) It may pass directly backward, and occupy the iliac fossa. This form is often mistaken for a retroperitoneal hernia, and its relation to the inguinal canal is forgotten. (3) It may pass downward and inward to the side of or in front of the bladder. This type has been called the inguinovesical or prevesical hernia.

*Etiology.*—Precise knowledge concerning the formation of properitoneal hernia is wanting, as is attested by the number of theories which have been advanced, of which only a few of the most logical can be discussed.

After making a meticulous study of the inguinal canal, Eppinger decided that its anatomical structure was such that it predisposed to the formation of properitoneal hernia. He arbitrarily divided the canal into three portions: (1) The innermost section, which extends from the internal inguinal ring to the point where the infundibuliform fascia pierces the transversalis muscle. In this portion of the canal the transversalis fascia is firmly adherent to the transversalis muscle, but only a few fibrous tissues connect it with the peritoneum, this space being filled with loose, non-resisting fatty tissue. (2) The middle portion of the canal, which is 10 to 12 centimetres long, and is surrounded by the internal oblique and transversalis muscles. Here the muscular reinforcement precludes the formation of interparietal hernias. (3) The anterior segment of the canal, which corresponds to the space between the internal oblique muscle and the external inguinal ring. The two oblique muscles are loosely attached to each other by strands of connective tissue, and the interstices are filled with loose, yielding, adipose tissue. It is thus evident that the weakest points in the inguinal canal are



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at the inner and anterior segments, and it is here that interparietal hernias are encountered clinically.

It has been observed that properitoneal hernia frequently is associated with conditions which prevent the normal descent of the hernial sac. Macready, Streubel, and Krönlein noticed that an ectopic testicle situated in the inguinal canal or just outside of the external inguinal ring obstructs the descent of a congenital hernia, and if the impulses from above continue, the hernial sac is forced between the layers of the abdominal wall. It must be remembered, however, that properitoneal hernias are found in males with normal testicles, and have been reported also as occurring in women; hence some other factors must operate in their production. Von Mosetig-Moorhof insists that a narrowing of the external inguinal ring permits the bowel to descend into the dilated inguinal canal but prevents its descent through the external ring, and therefore, the hernial sac insinuates itself between the abdominal muscles. In support of this theory, Tillaux describes a case of properitoneal hernia in which the opening of the external ring was so small that it barely permitted the passage of a nerve, much less an enterocele. Butz and Bramann cite a case in which the external ring was entirely absent, yet a properitoneal hernia was found. Moynihan believes that a defective formation of the scrotum results in an ectopic process vaginalis and testes, with resulting obstruction to the descent of a coexisting congenital hernia. Coley encountered a case in which a hydrocele in the canal of Nuck acted as a barrier to the descent of a congenital enterocele and caused a properitoneal hernia. Streubel maintains that an ill-fitting truss which permits the canal to remain open and merely presses over the external ring causes a mechanical obstruction which predisposes to the formation of interparietal hernia. According to Birkett, this theory is untenable, as malposition of a truss is very common and the occurrence of this hernia is infrequent.

It has been suggested that a narrowing of the internal inguinal ring might prevent the replacement of a large hernia into the peritoneal cavity. Gosselin and Streubel pointed out that if the internal inguinal ring was constricted and pressure was exerted from below, as in repeated and indiscriminate taxis, it might cause a bulging of the neck of the sac between the peritoneum and the transversalis fascia. By pressure over a large scrotal enterocele, Corner was able to force the intestines into a properitoneal sac, and by pressure over the properitoneal swelling, the hernial content immediately descended into the scrotum. While doing the herniorrhaphy, he was able to repeat this phenomenon, and found a narrow internal ring which diverted the scrotal contents into the properitoneal sac. Many of the so-called reductions en masse were merely instances in which the scrotal hernia was forced into a preformed properitoneal sac. The accepted explanation of reduction en masse is that an inguinal or crural sac, by repeated and forcible manipulation, is separated from its surrounding structures, and is invaginated or pushed back into the abdominal cavity without disturbing the mutual rela-



tionship between the sac and its content. The reduced hernia always lies outside of the peritoneum.

To us it seems that the difficulty encountered in separating a hernial sac from its surrounding structures during herniorrhaphy would preclude dislocation of the hernial sac en masse by simple taxis. Streubel and Halstead believe that such cases of reduction en masse are merely the transference of the content of a scrotal or crural sac into a preformed properitoneal sac. Moynihan reviewed the specimens of reduction en masse in Guy's Hospital Museum, and concluded that most of them were from cases of properitoneal hernia. In studying the reports of cases of reduction en masse, we found that the description of the operative findings was so meager that the true anatomical position of the sacs could not be determined. We agree with Halstead and Moynihan, however, that examples of true reduction en masse are rare, and that most of the cases which purport to be of this nature are really cases of properitoneal hernia.

In contrast with the theory of the mechanical origin of properitoneal hernia are the arguments of those who believe that all hernias are congenital. Rokitsky pointed out that in many cases small peritoneal pouches or diverticula could be seen in the immediate neighborhood of the internal inguinal ring; these, he believes, constitute the anlage of properitoneal hernia. Brunner, Englisch, and Wagner also noticed these small peritoneal pouches, and thought them responsible for interparietal hernias. In 1884, Wagner confirmed his convictions by finding a case of inguinal hernia with a coëxisting properitoneal hernia which lay adjacent to the inguinal canal but did not communicate with it. Russell maintains that all hernias are congenital, and that the process vaginalis can be caught up between the layers of the abdominal muscles and form any variety of interparietal hernia. In a series of 200 post-mortem examinations, Raw and Murray found sixty-eight peritoneal diverticula, fifty-two of them being femoral, thirteen inguinal, and three umbilical. Murray believes that when these congenital diverticula or pouches exist, the occurrence of hernia depends on the size of the opening and the strength of the muscles that protect the orifice.

Coughlin's anatomical studies of adults and Moynihan's of fetuses revealed that in 22 per cent. of necropsies they could clearly demonstrate deep peritoneal pouches or fossæ near the obliterated hypogastric artery which easily could have developed into properitoneal hernias.

Kirchner reports a case of such a properitoneal hernia arising in Hesselbach's triangle as the result of a peritoneal diverticulum near the obliterated hypogastric artery. How can the occurrence of multiple hernias in the same individual be explained unless the theory of their congenital origin is accepted? Bainbridge operated on a woman in whom six separate and distinct hernias were present. Congenital malformation of a hernial sac is evident in the bifid or pantaloons hernias of Halstead, in which the inguinal sac is divided into two compartments like a pair of trousers and opens into the abdominal cavity through a normal internal inguinal ring.

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Schmidt demonstrated that there might be a congenital dislocation of the internal inguinal ring upward and outward. As a result of the displacement, the spermatic cord would be too short to reach the scrotum, and an ectopic testicle would result. He convinced Oberst, Trendelenberg, Zeller, and Link that this theory was correct, but we have been able to collect only three cases which substantiate this view, those of Schmidt, Bramann, and Hölder.

It must be self-evident, therefore, that the pathogenesis of properitoneal hernia cannot be ascribed to a single cause, but rather to a combination of many factors.

*Incidence and Sex.*—The incidence of properitoneal hernia is a subject of much controversy. Bull and Coley found but one case out of 5,000 consecutive herniotomies, while Kirchner observed two cases out of 500. We believe that the frequency of properitoneal hernia is greater than these figures indicate, and that many cases have remained undiagnosed.

Both sexes are affected, but the condition is much more common in the male than in the female because of the greater percentage of congenital anomalies which are present in the male inguinal region. Of the cases collected since 1900, thirty-three have been reported in males and nine in females, and in eight the sex was not mentioned.

All ages are involved, the youngest patient being fifteen and the oldest seventy-five. The average age for the male is thirty-eight, the greatest number of cases occurring between the ages of thirty and fifty years, which is the period of greatest muscular activity. In women the average age is fifty-five.

The right side is involved more frequently than the left, because of the greater percentage of congenital anomalies associated with the later closing of the right vaginal process. In Göbell's series of sixty cases, thirty-seven occurred on the right side and twenty-three on the left. In our collection, twelve were found on the right side and eight on the left, the side not being mentioned in thirty cases.

*Symptoms.*—There is no pathognomonic sign or symptom that will lead to the diagnosis of properitoneal hernia. Fully 90 per cent. of the patients will present themselves with the clinical syndrome of acute intestinal obstruction. They may have had a reducible inguinal or femoral hernia of long standing. Following an apparent reduction, the patient becomes nauseated and vomits, the abdomen becomes distended, and the bowels constipated. On examination, an irreducible inguinal or femoral hernia may be found, with some tenderness over the region of the internal inguinal ring, but as a rule no swelling occurs above Poupart's ligament. Of Breiter's thirty-six cases, a swelling was felt above Poupart's ligament in twenty-two. Moynihan disbelieves Breiter's contention, and corroborates his views by an examination of all specimens of properitoneal hernia in the museum of Guy's Hospital in which he found the position of the interstitial sac to be such that it precluded recognition on abdominal examination. In rare instances the content of the inguinal hernia may be reduced into the properitoneal sac, and then

the diagnosis is obvious. In those cases in which there is no accompanying inguinal or femoral hernia, it is usually impossible to make a pre-operative diagnosis.

It is only by operation or post-mortem examination that the true nature of the hernia is revealed. Many surgeons have performed a herniotomy for strangulated inguinal hernia, removed the sac, and closed the wound, but when, to their surprise, symptoms of obstruction persisted and a subsequent operation was performed, a strangulated properitoneal hernia was found.

Of the cases reported since 1900 that we have collected, thirty-four were strangulated or incarcerated, four were reducible, and in twelve no history was given. The failure to make an early diagnosis and the resultant delayed operative intervention has resulted in a high rate of mortality. Torrey in 1888 reported thirty-five cases of strangulated properitoneal hernia, with an operative mortality of 80 per cent. In our series of fifty herniorrhaphies, there were ten deaths, and in twenty cases the results were not known, making a mortality of 20 per cent. or more.

The treatment of properitoneal hernia will be considered jointly with the treatment of the other types of interparietal hernias.

#### INTERSTITIAL HERNIA

The two cases we have presented are typical of this group of interparietal hernia. (See Cases I and II.)

From an autopsy specimen, Hesselbach, in 1814, presented an excellent illustration of this variety of hernia, with the sac lying between the internal and external oblique muscles. In 1812, Cooper observed and, in 1827, published an account of the first successful herniotomy for a strangulated interstitial hernia, the sac being situated between the two oblique muscles. In 1893, Macready was able to gather 163 cases of this form of hernia from the records of the London Truss Society, but as these cases were not verified by autopsy or operative findings, their diagnosis is uncertain. Interstitial hernia in women was first described by Berger in 1891, and Auvray in 1900 reported fourteen such cases. In 1900 Göbell collected 115 cases of interstitial hernia which had been found at operation or post-mortem examination. We have been able to gather sixty-five cases from the literature and have made two personal observations, making our series a total of sixty-seven. These, added to the figures reported by Macready and Göbell, make a grand total of 345 known cases of interstitial hernia.

*Definition and Anatomical Considerations.*—In interstitial hernia the sac burrows its way between the layers of the abdominal wall, and may be found in any of the following positions: (1) Between the transversalis muscle and fascia; (2) between the transversalis and internal oblique muscles; (3) between the fibres of the internal oblique muscle; or (4) between the internal and external oblique muscles, the latter being by far the most common position. Many writers contend that the only variety seen is the form in which the sac lies between the two oblique muscles. Moynihan even goes

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so far as to deny the possibility of other forms because he believes the anatomic structure of the inguinal canal is such as to preclude the formation of intermuscular hernias in this section of the canal.

We have been able, however, to collect authentic cases of all four types of interstitial hernia mentioned above. Göbell reports eleven cases in which the hernial sac was located between the transversalis muscle and fascia, typifying Group 1. He also found fifteen cases in which the hernial sac lay between the external oblique muscle and the transversalis fascia, the internal oblique and transversalis muscles being deficient in this area. As in every one of his cases the hernia was incarcerated, the exact anatomical position was determined during the operation. Coley and Sultan each describe a case in which the sac is situated between the fibres of the internal oblique and the transversalis muscles (Group 2). Illustrative of Group 3, Goyrand, Berger,

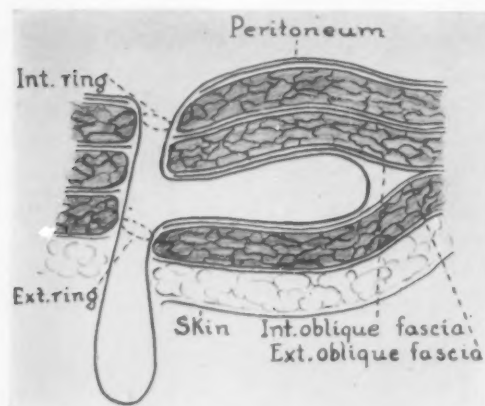


FIG. 3.—Bilocular interstitial hernia.

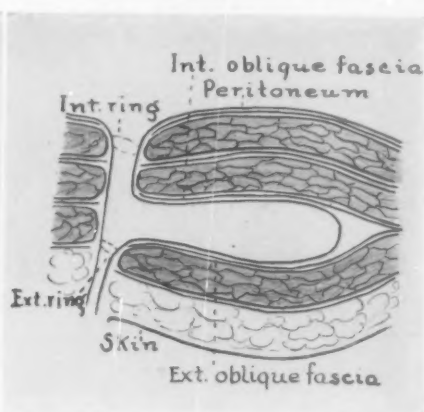


FIG. 4.—Monolocular interstitial hernia.

and Venturoli have seen the hernial sac completely surrounded by the filaments of the internal oblique muscle. Goyrand, indeed, considers it characteristic, and believes that the hernial sac insinuates itself between the muscle fibres. In Berger's case, the man had a congenital monolocular hernia of the right side, and the hernial sac was surrounded by muscular fibres of the internal oblique muscle. Venturoli had to sever the filaments of the internal oblique muscle in order to release the incarcerated hernial sac. Group 4 consists of the intermuscular hernias most commonly encountered—those situated between the two oblique muscles. Thus it seems to us that there is definite clinical evidence as to the existence of all four varieties of interstitial hernia.

Moynihan, Halstead, and Watson all assert that an interstitial hernia must be bilocular (Fig. 3). One loculus must extend down the inguinal canal through the external ring and may or may not descend into the scrotum; the other loculus must pass out between the external and internal oblique muscles, and both loculi must communicate with each other and open into the peritoneal cavity through the internal inguinal ring. However, all inter-



stitial hernias are not bilocular, for cases have been described which demonstrate that both trilocular and monolocular forms exist.

In Ehler's interstitial hernia there were three sacs, one extending between the internal and external oblique muscles, one between the skin and superficial fascia, and the third descended into the scrotum. All three loculi communicated with each other and opened into the abdominal cavity through the internal inguinal ring. In the monolocular variety (Fig. 4), the interstitial sac is a direct continuation of the inguinal hernia and not a diverticulum with an inguinal hernia descending farther down the canal. If the ectopic testicle is at the external ring and prevents the further descent of the hernia, the only direction in which the sac can expand is between the layers of the abdominal muscles. As there is no loculus going down into the scrotum, the hernia must of necessity be monolocular. At operation, the enterocele

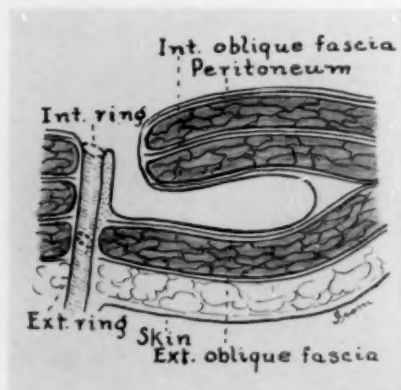


FIG. 5.—The authors' case of interstitial hernia occurring outside the inguinal canal.

between the muscles is found to be a direct continuation of the sac that comes down the inguinal canal, while the process vaginalis is completely closed and in the majority of cases does not even descend into the malformed, empty scrotum. Göbell was able to collect reports of twenty-four such cases of monolocular interstitial hernias and eighty-four of the bilocular variety. In our series there were ten monolocular, thirty-six bilocular, and twenty-one that could not be diagnosed because of insufficient data.

In another variety of monolocular hernia the interstitial sac lies adjacent to but not communicating with the inguinal canal (Fig. 5), and opens into the abdominal cavity through its own orifice, which lies near the internal inguinal ring. Kirchner describes such a case in which the sac does not involve the inguinal canal or the internal inguinal ring, but occurs as a separate and distinct entity. In the two cases which we have reported in this paper, the interstitial sac was completely outside the inguinal canal, and may be classified as an extra-inguinal hernia of the interstitial variety. Perhaps some writers would consider this group as a form of ventral hernia, but its immediate proximity to the inguinal canal precludes this supposition.

*Etiology.*—The same condition that contributes to the formation of properitoneal hernia contributes also to the production of the interstitial variety. The most satisfactory explanation of this form of rupture is based upon its connection with retained testicles. The testicle usually is situated at or just outside of the inguinal ring, and bars the further descent of the hernial sac, causing it to spread between the layers of the abdominal muscles. In Macready's 129 cases in males, abnormalities of the testicles were present in 73.4 per cent., and in 67.1 per cent. there were congenital displacements of



## INTERPARIETAL HERNIAS

the testicles. In Göbell's 111 cases of interstitial hernia in males, abnormally placed testicles were present in fifty-seven, or 51.3 per cent. Since 1900, forty-five interstitial hernias in men have been reported, and twenty-five (55.5 per cent.) of the patients had ectopic testicles. De Garmo describes two cases in which a tube and an ovary were found in the inguinal canal mechanically obstructing the descent of a congenital hernia. The cases of Macready and Göbell, combined with our series produce a total of 285 cases of interstitial hernia in males, in 186 of which the factor of retained testes was present, making a total of 65 per cent. with congenital aberrant testes. Macready states that in practically all hernias of this group there is a mal-development of the scrotum which prevents the normal descent of the testicle and process vaginalis. Moynihan strengthens this belief by showing that the scrotum is never fully occupied by the testicle.

That an ectopic testicle is not the only etiologic factor present, however, is evidenced by the occurrence of interstitial hernia in males with normally placed testicles, and in females. Our series includes the records of twenty-two women in whom interstitial hernias were present.

We believe that the preformed pouches of Rokitansky play a lesser part in the formation of these hernias than in the properitoneal variety; yet how can we explain the existence of the form of interstitial hernia which occurs separately from the inguinal canal unless we accept the premise that it developed in a congenitally preformed sac? The case of Kirchner, together with our two cases, illustrates this form of hernia.

*Incidence.*—The incidence of interstitial hernia seems to vary, as Langton observed forty-two in 50,000 herniorrhaphies, while Remedi encountered twelve in only 760 such operations. The condition occurs 3.5 times more frequently in men than in women. In Göbell's series of 115 cases, four were in women. Of Macready's 163 interstitial hernias, thirty-four were in females, while Auvray reports fourteen and Berger eight cases in women. Thus far we have been able to find 285 interstitial hernias in men and eighty-two in women. The average age incidence in males was thirty-six and in females fifty-six. The youngest patient reported was four months old and the oldest sixty-six.

*Symptoms.*—The outstanding clinical syndrome is that of intestinal obstruction, as evidenced by the fact that in Göbell's 115 cases, ninety-seven hernias were incarcerated. In our series thirty were incarcerated, fourteen were reducible, and in twenty-three no history was given. If a patient complains of pain in the inguinal region, is nauseated and vomits, and if examination reveals an ectopic testicle with a palpable mass above Poupart's ligament, the presence of interstitial hernia should be suspected. The intermuscular swelling, however, cannot always be palpated, the testes may be in the scrotum, and the obstructive symptoms may be missing. In such cases the diagnosis is difficult and, in fact, impossible. In our two cases no obstructive symptoms were present. Both patients complained of pain in the inguinal region which was accentuated by straining and was relieved by lying down.

No inguinal mass was present. We surmised that we were dealing with some abnormal form of hernia, the exact nature of which we did not know.

SUPERFICIAL HERNIA

Boyer, in 1822, was the first to describe a hernia which proceeded from the external inguinal ring and spread out between the aponeurosis of the external oblique muscle and the integument. He termed it intra-inguinal hernia. In 1886, Le Fort revived interest in this variety of hernia, but it remained for Kuester, in 1887, clearly to describe and define this rare condition, which he named inguinoperforating hernia. He presented histories of fourteen cases and discussed the probable etiologic factors concerned in their production. In 1903, Moschowitz collected sixteen cases and added one of his own. In 1905, Sellenings published reports of a series of twenty-seven cases which he had collected. In a review of the literature we have been able to accumulate records of ninety-six cases, some of which date back to 1893 and are not included in any of the aforementioned series. We realize that it is a hopeless task to collect all reported cases because of the variety of titles and subjects under which they have been published. Many reports of so-called superficial inguinal hernias had to be discarded because of insufficient data which made it impossible to determine accurately their anatomical position.

The addition to our series of that of Sellenings produces a total of 123 authentic cases of superficial hernia.

*Definition and Anatomical Considerations.*—In inguinoperforating hernia the sac descends into the inguinal canal, then through the external inguinal ring, and spreads out between the aponeurosis of the external oblique muscle and the skin. The sac may occupy one of three positions: (1) It may pass laterally toward the anterosuperior iliac spine. This is the most common location. (2) It may extend upward and medialward toward the umbilicus, as in Broca's case. (3) It may pass downward over Poupart's ligament and come to lie directly over the femoral opening between the deep fascia of the thigh and the skin.

Cases belonging to the last group have often been described as inguinofemoral hernia. In fact, Twyman considers them a clinical entity and reports the cases of Holthouse, Key, and his own as being representative of this variety. It seems to us that these are true inguinoperforating hernias, and should be so classified. An inguinofemoral hernia, as the name implies, is one involving both inguinal and femoral canals. For example, an inguinal hernia passes down the inguinal canal as far as the lower part of the canal; then because of an anatomical defect it passes beneath Poupart's ligament and emerges through the femoral opening. In Twyman's case the hernial sac came through the external inguinal ring, passed downward over Poupart's ligament, and was found in the superficial tissue in Scarpa's area. The hernia was inguinal, and never came into contact with the femoral canal; hence it is merely a superficial inguinal hernia, and should be so classified.

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The bilocular theory of Moynihan again is applicable to this form of hernia, one loculus passing down into the scrotum or labia and the other passing out between the aponeurosis and the integument. (Fig. 6). It is true that in some cases the superficial hernia is merely a diverticulum from the process vaginalis and that the main portion of the hernia descends into or near the scrotum. On the other hand, we have found cases in which the process vaginalis is situated between the external oblique aponeurosis and the skin, there being no hernial sac descending into the scrotum. When the process vaginalis and the testicle are both ectopic, it seems that they constitute true monolocular hernia. Göbell maintains that the monolocular variety is just as prevalent in the superficial hernias as in the other forms of interparietal hernias which have been discussed so far (Fig. 7). In our series of ninety-six cases of superficial hernias, thirty were bilocular, ten monolocular,

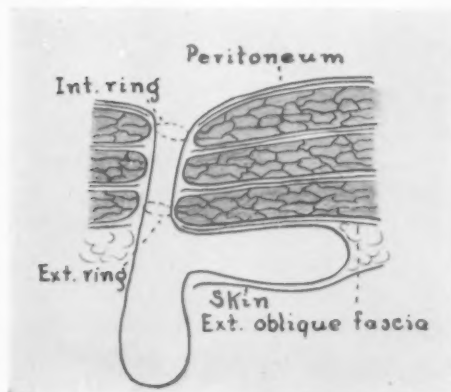


FIG. 6.—Bilocular superficial hernia.

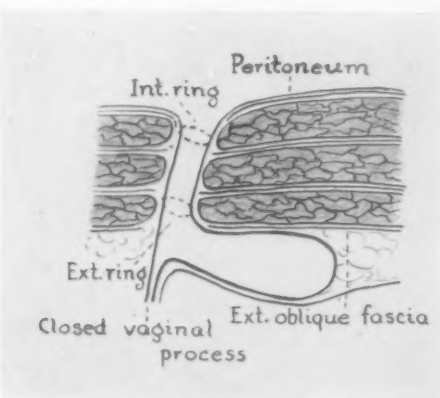


FIG. 7.—Monolocular superficial hernia.

and in fifty-six insufficient data made it impossible to determine the nature of the interstitial sac.

*Etiology.*—Practically all that has been said concerning the etiology of properitoneal and interstitial hernia could be mentioned as being causative factors in the formation of superficial hernias. The pathogenesis of this variety of hernia, however, is concerned chiefly with congenital malformations of the process vaginalis and the testicles. As a rule, both are placed between the skin and the external oblique aponeurosis, and very seldom communicate with the scrotum. In those few cases in which the process vaginalis and the testicle enter the scrotum, the superficial hernia is merely a diverticulum from the walls of the scrotal hernia. In other cases the testicle is ectopic, but the vaginal process enters the scrotum, although it is completely obliterated below the testicle. The spermatic cord usually is short, and Schmidt considers this a factor in inhibiting the normal descent of the testicle. In 1900, Göbell collected eighteen cases of superficial inguinal hernia. In all of these the testes were ectopic, in eleven the sac was bilocular, and in three it was monolocular. In our series of cases eighty-six were in males, in sixty-seven of whom ectopic testicles were present.

However, as eight cases were found in males with normally placed testicles and seven were found in females, other etiologic factors must be sought. If the content of the hernial sac is suddenly increased and the scrotum cannot adequately take care of it, then the hernia must extend out between the external oblique aponeurosis and the integument. Moschowitz reports a case in which a testicle was retained in the inguinal canal. As the boy developed, the testicle gradually descended into the scrotum, but since the descent was accompanied by pain, he frequently forced the testicle and the accompanying congenital hernia back out of the scrotum. Following such a reduction, the testicle and hernia were forced out between the external oblique aponeurosis and the skin, as the external inguinal ring was too small to permit their return into the inguinal canal and abdomen. The hernia became strangulated, and at operation the sac was found to be as described. Repeated and indiscriminate taxis, therefore, may produce this form of hernia.

*Incidence.*—The incidence of this group is very low. So far, only 123 cases have been described, 101 in males and seven in females, and in fifteen the sex was not mentioned. The average age is forty-five years.

*Symptoms.*—The symptoms of superficial hernia usually are those of intestinal obstruction. Out of ninety-six cases, thirty were irreducible and presented symptoms of obstruction, twelve were reducible, and in fifty-four no clinical history was given. In this type, a palpable tumor generally is encountered about Poupart's ligament, and when the scrotum is examined the testicle is missing. It must be remembered, however, that in a few cases the superficial sac may pass downward into the region of the femoral ring and be mistaken for a femoral hernia.

#### TREATMENT OF INTERPARIETAL HERNIA

As most interparietal hernias are either incarcerated or strangulated when the patient presents himself, immediate operative intervention is indicated. Delay merely increases the risk of mortality. If a patient presents symptoms of intestinal obstruction following an inguinal or femoral herniorrhaphy, an incarcerated properitoneal hernia should be suspected, and intervention should be instituted immediately. In all herniotomies, in order to be certain that an intermuscular sac has not been missed, the entire inguinal canal should be carefully explored. When operating on an interparietal hernia, the surgeon must remember that the strangulation may be at the internal ring, the neck of the interstitial diverticulum or sac, or the external ring. The abdomen never should be closed until the site of obstruction has been found. Generally, careful exploration will reveal the enterocele in a diverticulum.

In an operation for interparietal hernia, some surgeons prefer the inguinal approach, and then, if necessary, the incision can be extended until the abdomen is opened. Moynihan thinks that a combined abdomino-inguinal route is better. It seems to us that the latter is the more practical, as it precludes injury to the bowel, since the site of obstruction is more clearly revealed by this approach.

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In dealing with simple non-strangulated hernias, all that is necessary is to isolate the sac, ligate it, and close the hernial tract through the abdominal parietes.

### SUMMARY

1. Interparietal hernia is a term used to designate a group of hernias which occur in the inguinal region between the various layers of the abdominal muscles, and are classified according to the anatomical location of the hernial sac.

2. Properitoneal hernia includes all those cases in which the hernial sac lies between the peritoneum and the transversalis fascia, 119 such cases being reported.

3. In interstitial hernia the sac lies between the transversalis fascia and muscle, between the transversalis and internal oblique muscles, or between the two oblique muscles, 348 such hernias having been reported.

4. In superficial hernia the sac lies between the skin and the aponeurosis of the external oblique muscle. We have found 123 cases of this type.

5. In interparietal hernia the sac may be monolocular or multilocular, the latter being the form present in the majority of cases.

6. The usual clinical picture is that of intestinal obstruction.

7. Treatment consists of early recognition and immediate relief by operation.

### BIBLIOGRAPHY

- Auvray, M.: Hernie inguino-interstitielle chez la femme (Hernie de Goyrand). *Gaz. hebdomadaire de Méd. et de Chir.*, vol. xlvii, pp. 542-547, 1900.
- Bainbridge, W. S.: Multiple Herniae. *Buffalo M. J.*, n. s., vol. xlv, pp. 566-568, 1904-5.
- Bartholin, T.: *Historiarum anatomicarum et medicarum rariorum centuriae v et vi. Accessit Joannis Rhodii mantissa anatomica.* Hafniae, typ. H. Gødiani, 1661.
- Berger, P.: Sur quelques variétés de la hernie inguinale congénitale chez la femme; en particulier, des hernies compliquées d'un kyste du canal de Nuck et des hernies en bissac. *Bull. et mém. Soc. de chir. de Par.*, n. s., vol. xvii, pp. 283-294, 1891.
- Birkett, J.: Hernia. In *Holmes' System of Surgery*, 2d ed., vol. iv, p. 706. William Wood & Co., New York, 1875.
- Boyer, A.: *Traité des maladies chirurgicales et des opérations qui leur conviennent.* Vol. viii, p. 227, Migneret, Paris, 1822.
- Bramann, F.: Der Processus vaginalis und sein Verhalten bei Störungen des Descensus testiculorum. *Arch. f. klin. Chir.*, vol. xl, pp. 137-168, 1890.
- Breiter, W.: Ueber die Hernia inguino- und cruro-properitonealis. *Beitr. z. klin. Chir.*, vol. xiii, pp. 659-713, 1895.
- Broca, A.: Hernie inguino-interstitielle. *Bull. Soc. anat. de Par.*, vol. lxiii, pp. 111-125, 1888.
- Brunner, C.: Ueber Harnblasenbrüche. *Deutsche Ztschr. f. chir.*, 1898, 47:121. *Herniologische Beobachtungen.* *Beitr. z. klin. chir.*, vol. iv, p. 1, 1889.
- Bull, W. T., and Coley, W. B.: Observations on the Mechanical and Operative Treatment of Hernia at the Hospital for Ruptured and Crippled of New York. *ANNALS OF SURGERY*, vol. xvii, pp. 527-541, 1893.
- Butz, R. V.: On Properitoneal Hernia. *Chir. Vestnik*, vol. iv, pp. 419-422, St. Petersburg, 1888.



## LOWER AND HICKEN

- Coley, W. B.: Double Inguinoperineal Herniæ, with Double Ectopic Testes. *ANNALS OF SURGERY*, vol. I, p. 638, 1909. Inguinal Hernia in the Female. *Ibid.*, pp. 609-629; Superficial Inguinal Hernia Associated with Undescended Left Testis. *ANNALS OF SURGERY*, vol. liii, p. 301, 1911. Hernia. *Syst. Surg. (Keen)*, vol. iv, pp. 109, 198, Philadelphia, 1908.
- Cooper, A. P.: The anatomy and Surgical Treatment of Abdominal Hernia. In two parts. 2d ed. by C. A. Key. Longman and others, London, 1827.
- Corner, E. M.: A Case of Strangulated Hernia, First in One, and Then in the Second Sac (a Hernia en bissac) of an Inguinal Hernia. *Med. Press and Circ.*, n. s., vol. xciv, p. 213, 1912.
- Coughlin, W. T.: Anatomical and Pathological Observation on the Formation of Hernia at Hesselbach's Triangle. *St. Louis Cour. Med.*, vol. xxxiii, pp. 336-339, 1905.
- De Garmo, W. B.: Abdominal Hernia; Its Diagnosis and Treatment. J. B. Lippincott Co., Philadelphia and London, 1907.
- Ehler, F.: Ueber einige Fälle von interparietalen Leistenbrüchen. *Arch. f. klin. Chir.*, vol. xcvi, pp. 1012-1034, 1911.
- Englisch: Hernia inguinalis incarcerata; Herniotomia; Peritonitis; Exitus letalis post decem horas; Plätzen des Darmes bei der Reposition. *Tod. Med. Chir. Centralbl.*, vol. xx, p. 304, 1885.
- Eppinger, H.: Beiträge zur pathologischen Anatomie der Hernien in der Leistengegend. *Internat. Beitr. z. wissensch. Med.*, vol. ii, pp. 357-422, 1891.
- Göbell, R.: Ueber interparietale Leistenbrüche. *Deutsche Ztschr. f. Chir.*, vol. lvi, pp. 1-45, 1900.
- Gosselin, L.: Leçons sur les hernies abdominales faites à la faculté de médecine de Paris. A. Delahaye, Paris, 1865.
- Goyrand, G.: De la hernie inguino-interstitielle. *Mém. de l'Acad. Roy.*, vol. v, pp. 14-30, Paris, 1835-36. Cited by Göbell.
- Halstead, A. E.: Inguino-properitoneal Hernia, Inguino-interstitial Hernia; Report of Cases. *ANNALS OF SURGERY*, vol. xliii, pp. 704-716, 1906; Strangulated Inguino-peritoneal Hernia; Reduction en masse; Operation; Recovery. *Med. and Surg. Rept.*, St. Luke's Hosp., pp. 90-100, Chicago, 1905; Left Inguino-interstitial Hernia; Hernia Inguino-subfacialis; Herniotomy; Recovery. *Ibid.*, pp. 100-106.
- Hesselbach, F. C.: Neuste anatomish-pathologische Untersuchungen über den Ursprung und das Fortschreiten der Leisten- und Schenkelbrücke. J. Stahel, Würzburg, 1814.
- Hölder, F.: Ueber Hernia properitonealis. *Beitr. z. klin. Chir.*, vol. vii, pp. 257-292, 1890-91.
- Holthouse, C.: Hernial and Other Tumors of the Groin and its Neighborhood. John Churchill and Sons, London, 1870.
- Howlett, E. H.: A Case of Properitoneal Hernia. *Quart. M. J.*, vol. x, pp. 336-339, 1901-2.
- Key, C. A.: Abstract of a Clinical Lecture on Strangulated Inguinal Hernia Delivered at Guy's Hospital, July 1, 1829. *Lond. Med. Gaz.*, vol. iv, p. 193, July 18, 1829.
- Kirchner, W. C. G.: Formation of Hernial Sac by the Obliterated Hypogastric Artery; Report of a Case. *St. Louis Cour. Med.*, vol. xxxiii, pp. 339-341, 1905; Properitoneal Hernia. *Trans. Am. Assn. Obst. and Gynec.*, 1912; vol. xxv, pp. 466-472, York, 1913; *Am. J. Obst.*, vol. lxvii, pp. 690-696, 1913.
- Krönlein, R. U.: Hernia inguino-properitonealis incarcerata. *Arch. f. klin. Chir.*, vol. xix, pp. 408-420, 1875-6; Weitere Mittheilungen über die Hernia inguino-properitonealis. *Ibid.*, vol. xxv, p. 548, 1880; Weitere Notiz über die Hernia inguino-properitonealis. *Ibid.*, vol. xxvi, p. 521, 1881.
- Kuester, E.: Beiträge zur Lehre von den Hernien. *Arch. f. klin. Chir.*, vol. xxxiv, pp. 202-221, 1887.

# INTERPARIETAL HERNIAS

- ✓ Langton, J.: The Bradshaw Lecture on the Association of Inguinal Hernia with Descent of the Testis. *Lancet*, vol. ii, pp. 1857-1864, December 29, 1900.
- Le Clerc, R.: Hernie propéritonéale crurale. *Bull. et mém. Soc. de chir. de Paris*, n. s., vol. xxxviii, pp. 437-439, 1913.
- Le Fort, L.: Sur un cas rare de hernie inguinale qu'on pourrait appeler préinguinale. *Bull. gén. de therap.*, vol. cx, pp. 49-55, 1886.
- Link: Zur Kasuistik der Hernia inguino-properitonealis. *Centralbl. f. Chir.*, vol. xix, pp. 82-84, 1892.
- Macready, J. F. C. H.: A Treatise on Ruptures. C. Griffin & Co., London, 1893.
- ✓ Moschcowitz, A. V.: Inguino-superficial hernia (Kuester). *Med. Rec.*, vol. lxiii, pp. 52-55, 1903.
- Moynihan, B. G. A.: Arris and Gale Lectures on the Anatomy and Pathology of the Rarer Forms of Hernia. *Lancet*, pp. 513-520, February 24, 1900.
- Murray, R. W.: Hernia; Its Cause and Treatment. 2d ed. P. Blakiston's Son & Co., Philadelphia, 1910.
- Novaro, N.: Delle ernie inguino-interparietali (inguino-superficiali, inguino-interstiziali, inguino-properitoneali). *Gass. internaz. di med.*, vol. xxiv, pp. 3-6, 1921.
- Oberst, M.: Ein Fall von incarcerirter Hernia inguina-properitonealis; Herniotomie; Heilung. *Centralbl. f. Chir.*, vol. x, pp. 65-68, 1883.
- Parise, J.: Mémoire sur deux variétés nouvelles de hernies, la hernie inguinale intra-iliaque et la hernie inguinale antévésicale. *Mém. Soc. de Chir. de Paris*, vol. ii, pp. 399-430, 1847-51.
- Petit, J. L.: Traité des maladies chirurgicales, et des opérations qui leur conviennent. Méquignon l'ainé, vol. ii, p. 217, Paris, 1790.
- Remedi, V.: Quoted by Novaro.
- Rokitansky, C.: A Manual of Pathological Anatomy, vol. ii, p. 12. The Sydenham Society, London, 1849.
- ✓ Russell, R. H.: Inguinal Herniæ. *Brit. J. Surg.*, vol. ix, pp. 502-508, April, 1922.
- Schmidt, M.: Zur Aufrechterhaltung meiner Erklärung für die Genese der Hernia inguino-interstitialis und Hernia inguino-properitonealis. *Arch. f. klin. Chir.*, vol. xli, pp. 292-304, 1891.
- Sellenings, A. E.: Superficial Inguinal Hernia, with Report of a Case. *Med. News*, vol. lxxxvi, pp. 489-491, 1905.
- Streubel, C. G.: Ueber die Scheintenduction bei Hernien, und insbesondere bei eingeklemmten Hernien. Leipzig, 1864.
- Sultan, G.: Atlas and Epitome of Abdominal Hernias. Translation from the German edited by William B. Coley. Philadelphia, 1902.
- Tillaux, P.: De la hernie inguino-interstitielle; rôle du taxis dans cette hernie. *Bull. gén. de therap.*, vol. lxxxi, pp. 209-217, 1871.
- ✓ Torrey, W. S.: Inguino-properitoneal Hernia. *ANNALS OF SURGERY*, vol. vii, pp. 161-170, 1888.
- Trendelenburg, F.: *Centralbl. f. Chir.* Original Referat., 1881. Cited by Göbell.
- Twyman, E. D.: Combined Inguinofemoral Hernia. *Surg. Gynec. and Obst.*, vol. xxvii, p. 182, August, 1918.
- Venturoli: *Novi Comment. acad. scient. institut. Bononiens*, T. iv., 1840. Schmidt's *Jahrbücher*, vol. xxxiii, p. 233. Cited by Göbell.
- Von Mosetig-Moorhof: Fall von Hernia inguino-properitonealis. *Wien. med. Wchnschr.*, vol. xxxv, pp. 257-260, 1885.
- Wagner, A.: Ueber die Hernia properitonealis. Dorpat, Schnakenburg, 1884.
- Watson, L. F.: Hernia, p. 163. C. V. Mosby Co., St. Louis, 1924.
- Zeller: Ein Fall von Hernia inguino-properitonealis incarcerata. *Medicin. Correspondenzblatt des Württemberg. ärztl. Landesvereins*, No. 32, 1887. Cited by Göbell.

## DUODENAL HERNIA

BY OLIN S. COFER, M.D., AND HAYWARD S. PHILLIPS, M.D.  
OF ATLANTA, GEORGIA

FROM THE DEPARTMENT OF SURGERY OF EMORY UNIVERSITY

WITHIN a period of three months, two cases of duodenal hernia were observed in the Surgical Service, Emory Division, Grady Hospital. They are of unusual interest in that one was of the left side and one of the right side according to the classification of Moynihan. Both cases were admitted with acute obstructive symptoms, the first diagnosed only by exploratory laparotomy with recovery, and the second diagnosed correctly but with a fatal termination.

From a search of available literature, the first description of duodenal hernia was by Klob, in 1861, who carefully described a case of the right-sided variety, though Trietz, in 1857, suggested the possibility of herniation at the duodeno-jejunal junction, describing anatomically the formation of the various folds and fossæ in this region.

A detailed analysis of reported cases was presented in 1906 by Moynihan, who, in his monograph, tabulated and explained the cases reviewed. Some one hundred case reports were embodied in this work and twenty of the patients recovered. The anatomic and embryologic interpretations of the two cases here reported are drawn from the descriptions detailed by him, though careful operative observations were made in both cases, supplemented by autopsy findings in the second case.

In order to properly report retroperitoneal hernia of this variety, it is necessary to review the embryology of the abdominal structures. The present theory is that, in common with most herniæ, a congenital potential sac must be present, which, in duodenal hernia, is formed by a fusion anomaly.

The intestinal canal at the fourth week of intra-uterine life is represented by a straight tube attached throughout its length to the mid-line of the body by a dorsal fold of peritoneum, the primitive mesentery. The stomach develops from a dorsal bulging of the tube, to which the primitive mesentery is attached, and a fold of peritoneum runs from the anterior abdominal wall, forming the lesser omentum.

By the sixth week, three segments supplied by special arteries are found. The first segment forms the stomach and duodenum and the celiac axis is contained within its mesentery. That portion of the mesentery lying behind the stomach forms, with the growth of the posterior wall of the stomach and its development to the right, the greater omentum. The head of the pancreas lies at the convex junction of the pylorus with the stomach. The distal end of the duodenum, where later the duodeno-jejunal flexure is found, lies in the median plane of the body, possesses no mesentery, and is therefore fixed to the posterior abdominal wall.

The second segment extends from the duodeno-jejunal flexure to the umbilicus and back to the posterior abdominal wall, the umbilical loop of Toldt, the two limbs of which are parallel and are united by a long, narrow mesentery containing the superior mesen-

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teric artery. This segment forms the jejunum, ileum, cæcum, ascending and transverse colon.

The third segment begins at the splenic flexure, includes the descending colon, sigmoid and rectum, and has a short, narrow mesentery, in which lies the inferior mesenteric artery.

The development of the peritoneal reflections of all the intra-abdominal organs is directly influenced by the growth of the organs themselves, and must of necessity occur within the narrow confines of the abdominal cavity. The stomach first lengthens its mesentery to form the greater omentum which extends without adhesions from the greater curvature to a dorsal position in the median line near the pancreas and spleen. The duodenum, with its ends stationary in the median line and its convexity behind, becomes, with the head of the pancreas, closely applied to the posterior abdominal wall, and finally by growth of other organs loses most of its mesentery. The second segment unfolds and enlarges rapidly in the proximal limb but more slowly in the distal limb so that the small intestines occupy the right half of the lower abdomen, and the cæcum and large intestine are cramped into the upper left regions, later to assume slowly their normal positions. The dorsal attachment containing the superior mesenteric artery trunk remains narrow and in a horizontal line. Physiologic adhesions, though not thoroughly understood, fuse layers in certain locations, but not in others. The fossa duodenalis divides into folds and fossæ. The pancreas, though first enclosed by peritoneum, loses the posterior layer by fusion and migration. The mesentery of the transverse colon blends with peritoneum covering the pancreas and the duodenum. The greater omentum fixes by fusion the transverse colon and forms the phrenocolic and the hepaticocolic ligaments. The final fusion is the development of the posterior abdominal wall at the expense of the descending mesocolon, which explains the position of the hernia between the stomach and transverse colon in the first case here reported.

According to Moynihan, the duodeno-jejunal junction is divided into nine fossæ, but only two of these are of sufficient clinical import to justify detailed description. Herniation through the remaining fossæ is extremely rare, but the proportional frequency in which each fossa is found in cases of duodenal hernia occurring either through the paraduodenal or the mesenterico-parietal fossa is given below.

(1) Superior duodenal fossa, which lies to the left of the ascending portion of the duodenum, and is present in 60 per cent. of all cases of duodenal hernia.

(2) The inferior duodenal fossa, or fossa of Treitz, lies to the left of the ascending portion of the duodenum between the third and fourth lumbar vertebra, and is present in 80 per cent. of all cases.

(3) The posterior duodenal fossa lies behind the upper part of the ascending limb of the duodenum, and is usually present in some degree.

(4) The duodeno-jejunal fossa lies at the base of the transverse mesocolon, and is found in about 15 per cent. of the cases.

(5) Inter-mesocolic fossa lies at the root of the transverse mesocolon, but runs horizontally in contra-distinction to the duodeno-jejunal fossa.

(6) The paraduodenal fossa, described in 1871 by Landzert, lies to the left of the ascending limb of the duodenum and is bound above by a fold containing the inferior mesenteric vein; to the left by a fold containing the left colic artery; below by a mesocolic fold, and to the right by the mesentery of the small intestine. Left-sided hernia usually occur through this fossa.

(7) The mesenterico-parietal fossa of Waldeyer lies behind the superior mesenteric artery and may be found by examining the first part of the meso-jejunum. The orifice is to the left and the blind extremity to the right and downward. Peritoneum of the left leaf of the mesentery lines the fossa, that of the right leaf covers the blind end and then is continued directly into the posterior parietal peritoneum. The second case reported occurred through this fossa.

(8) The intra-duodenal fossa, which is not often present.

(9) The parajejunal fossa also lies behind the superior mesenteric artery and is closely associated with the fossa of Waldeyer.

CASE I.—(Figs. 1, 3, and 4.) A negro male, thirty years of age, was admitted to Emory Division of Grady Hospital at 9:30 P.M., July 30, 1930, in extreme abdominal pain and shock. At 10:00 A.M. he had been taken with sudden, agonizing and paroxysmal pain over the entire abdomen, followed by vomiting a few minutes later and had retained nothing since. Notwithstanding the severity and constancy of the pain, he had not sought relief until twelve hours after the onset. For the past two or three hours he had been voiding an ounce or two of urine every ten or fifteen minutes and felt as if the bladder were filled. Except for a gnawing pain in the epigastrium three or four hours after meals occasionally, there have been no digestive disturbances.

The family history is unimportant and the past history is irrelevant.

The temperature was 97° Fahrenheit, pulse 84, and respiration 26. Leucocyte count was 14,100 with 81 per cent. neutrophils. One-half ounce of urine secured by catheterization was negative.

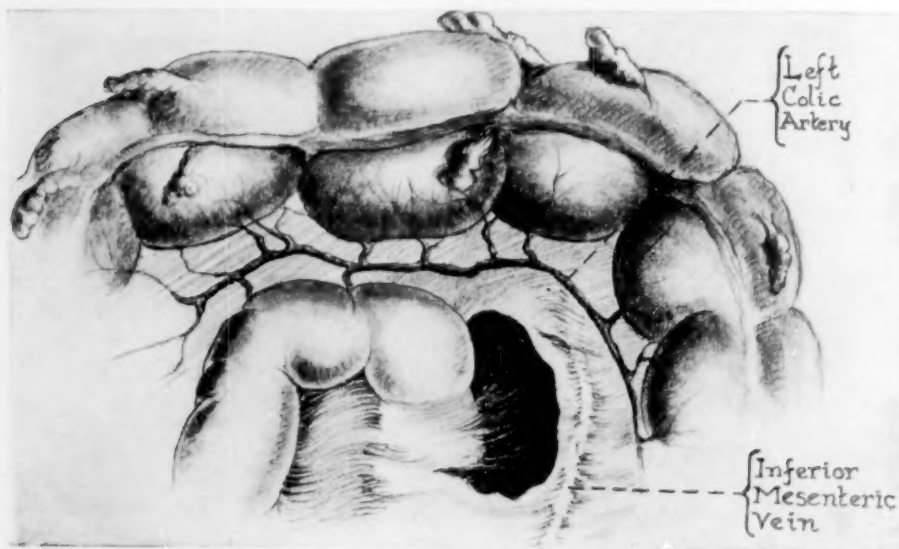


FIG. 1.—Paraduodenal fossa. (Moynihan.) Case I. Note left colic artery lateral to inferior mesenteric vein, which lies in left and upper falciform edge of fossa.

Physical examination was negative except for a symmetrical tumor, which apparently filled two-thirds of the abdomen. The tumor was smooth and firm and filled the lower abdomen and extended in the mid-line about four centimetres above the umbilicus. There was a dull note upon percussion and the entire abdomen was exquisitely tender. A diagnosis of acute intestinal obstruction of unknown etiology was made. Under ether anaesthesia a long right rectus incision with the umbilicus at its upper third was made. A smooth, symmetrical tumor, which occupied two-thirds of the abdomen and resembled and ordinary ovarian cyst, was found. The inferior pole telescoped the bladder, the omentum was stretched over the tumor and presented a moss-like appearance; the greater curvature of the stomach lay upon the superior pole and the small intestines were not visible, nor could they be seen through the cyst-wall. The caecum was exposed with difficulty but a redundant sigmoid was easily found. The sac was incised and all the small intestines from the jejunum to the lower ileum were found within. Reduction was accomplished by unfolding the root of the mesentery, upon which the hernial orifice was found to be at the duodeno-jejunal junction. Reduction was completed by



## DUODENAL HERNIA

drawing the entire small intestine through the neck of the sac in the paraduodenal fossa. The opening was closed by purse-string sutures, avoiding the inferior mesenteric vein. Convalescence was uneventful and patient left the hospital in two and one-half weeks.

CASE II.—(Figs. 2 and 5.) A negro male, aged twenty-two, was admitted October 9, 1930, at 7 P.M. Twenty-four hours before admission he had been taken with acute colicky pains, paroxysmal in character, beginning in the epigastrium and radiating over the entire abdomen. Persistent nausea and vomiting followed one hour later. Bowels had moved twice, the last time with considerable gas six hours before admission.

A similar attack, lasting six or eight hours, occurred when he was eleven years of age.

When admitted he was in acute pain with knees drawn up. The slightest palpation over any part of the abdomen was extremely painful, and marked rigidity, particularly on the right side, was present. The abdomen was domed-shaped and though a definite palpable mass was not present, inspection revealed a ridgelike elevation running from a point to the right and below the umbilicus to the left upper quadrant with definite

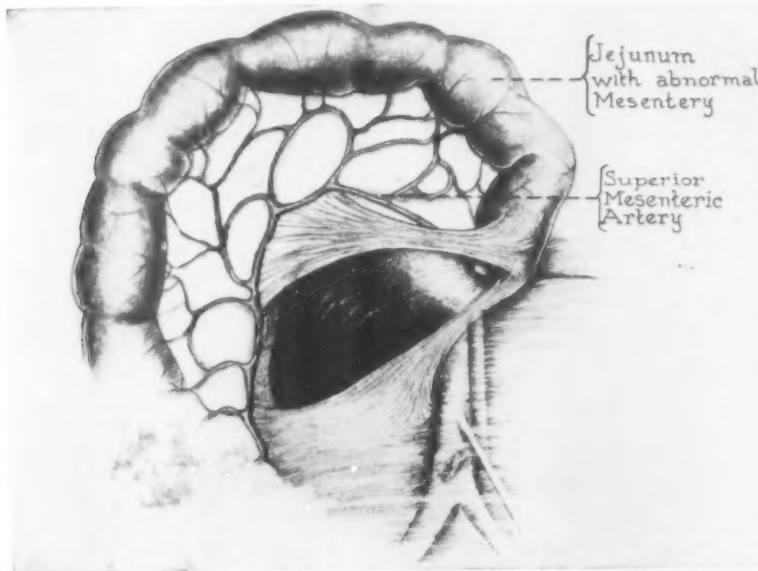


FIG. 2.—Mesenterico-parietal fossa of Waldeyer. (Moynihan.) Case II. Jejunum is shown raised upward and to left. Note superior mesenteric artery along superior and mesial border of fossa.

flatness throughout the rest of the abdomen. The temperature was 98° Fahrenheit, pulse 90, and respiration 30.

Under spinal anaesthesia a long right rectus incision was made and a large amount of dark reddish fluid escaped from the peritoneal cavity, after which four or five feet of gangrenous distended small intestine were extruded into the wound. There was a mass lying under the posterior parietal peritoneum extending from just above and to the left of the umbilicus, obliquely downward and occupying the right side of the abdomen. The colon occupied its normal position and it was found that the two loops of gangrenous intestines entered an opening at the root of the mesentery about the level of the umbilicus. All the small intestine except four or five inches of viable terminal ileum and a four-foot loop of gangrenous ileum lying free in the abdominal cavity were found in the sac. An enterostomy was performed after resection of the gangrenous loop, but no further operative procedures were carried out because of the precarious condition of the patient. Death occurred twenty-four hours later and the autopsy findings confirmed the diagnosis.

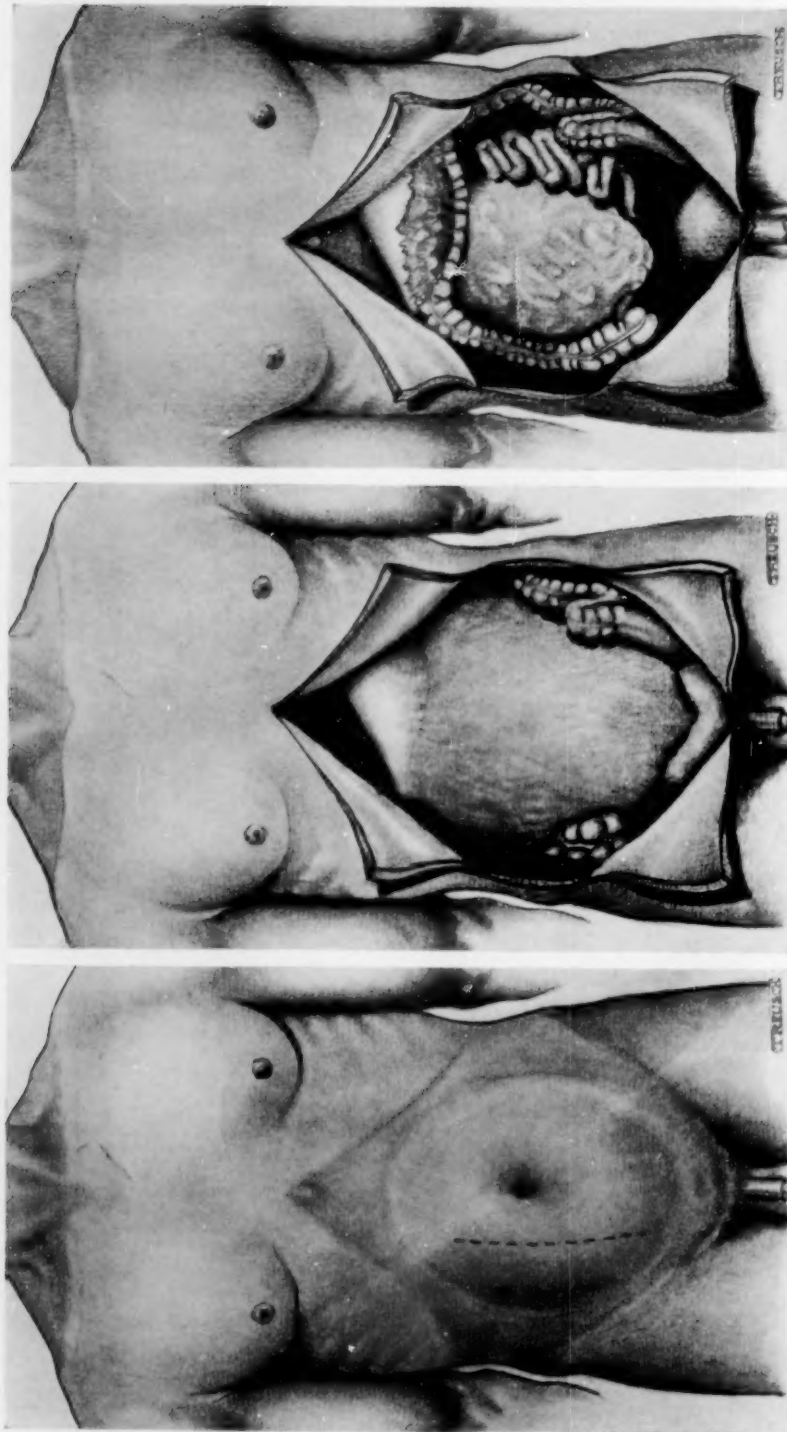


FIG. 3.

FIG. 3.—Case I. Before incision. Symmetrical tumor is clearly shown. A slight break in the symmetry of the tumor is found at the left costal margin but

FIG. 4.

FIG. 4.—Case I. Operation with recovery, but artist has shown wide dissection in order to demonstrate pathology. Omentum is shown stretched over tumor, which telescopes the bladder. Transverse colon lies posterior to the lower pole.

FIG. 5.—Case II. Shows gangrenous terminal ileum outside the sac though the intestine within the sac was viable. The gangrene was due to traction upon and consequent thrombosis of the intestinal branches of the superior mesenteric artery. The terminal four inches of ileum and caecum were not gangrenous because the ileo-colic artery was not thrombosed.

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The first case was free from symptoms for eight months, at which time he was admitted with symptoms very similar to those originally present, except to a lesser degree, but operation revealed only multiple abdominal adhesions probably due to trauma from drawing the entire small intestine through the hernial orifice, but there was no evidence of a recurrence of the hernia. The adhesions were released and convalescence was uneventful, the patient leaving the hospital at the end of the third week. He is now clinically well.

### BIBLIOGRAPHY

- <sup>1</sup> Moynihan: Retro-peritoneal Hernia. William Wood and Co., N. Y., 1906.
- <sup>2</sup> Trietz, W.: Hernia Retro-peritonealis. Prag., 1857.
- <sup>3</sup> Barrs, A. C.: Hernia Retro-peritoneal. *Lancet*, vol. ii, p. 286, August 8, 1891.
- <sup>4</sup> Waldeyer: Hernia retro-peritonealis nebst Bemerkungen zur anatomie des Peritoneums. *Archiv fur pathologiache, Anatomie und Physiology*, Berlin, 1872.
- <sup>5</sup> Landzert: Retro-peritoneal Hernia (Trietz) and Its Relations to Duodeno-jejunal Fossa. *St. Petersburg Medicinische Zeitschrift*, N F ii, p. 350, and N F ii, p. 306, 1871.
- <sup>6</sup> Short: Retro-peritoneal Hernia with Report on Literature. *British Journal of Surgery*, vol. xii, No. 47, pp. 455-464, January, 1925.
- <sup>7</sup> Lower, and Higgins: Retro-peritoneal Hernia. *ANNALS OF SURGERY*, vol. lxxxii, pp. 576-583, October, 1925.

## THE RÖNTGENOGRAPHIC VISUALIZATION OF THE ARTERIES OF THE EXTREMITIES IN PERIPHERAL VASCULAR DISEASE

BY HERMAN E. PEARSE, JR., M.D., AND STAFFORD L. WARREN, M.D.

OF ROCHESTER, NEW YORK

FROM THE DEPARTMENTS OF SURGERY AND MEDICINE, DIVISION OF RADIOLOGY OF THE UNIVERSITY OF ROCHESTER

IN THE care of vascular disease of the extremities, an accurate pre-operative determination of the state of the circulation should be made. To accomplish this end many tests have been devised to ascertain the influence of vasomotor spasm, the adequacy of the collateral circulation and the patency of the main channels. Recently, in the publications of Brown,<sup>3</sup> White,<sup>18</sup> and Morton and Scott,<sup>13</sup> tests for the evaluation of vasomotor overactivity have been suggested. The latter authors have demonstrated<sup>13</sup> the normal vasomotor gradient and the usual level of vasodilatation under given conditions and hence have been able to estimate, in any given case, how much of the peripheral vascular insufficiency is due to vasospasm and how much to organic obliteration.

In the large group of obliterative vascular diseases there have been no safe, exact methods for the determination of the state of the vessels. It is well known that in some of these disorders—for instance, thrombo-angiitis obliterans—the main arteries are apt to be occluded and the circulation carried on by the smaller collateral vessels. On the other hand, as is frequently the case in peripheral arteriosclerosis, the smaller arterioles may be obliterated while the larger trunks remain patent. Thus it follows that investigation of the arterial circulation in patients with organic involvement of the vessels should include information concerning not only the main channels, but also the smaller arteriolar branches. This is especially necessary if surgical intervention is contemplated. In the past, many indirect methods have been applied to achieve this end. The condition of the major arteries may be determined by palpation for perceptible pulsation in the vessels, by the application of the Pachon oscillometer or by the use of the recording sphygmomanometer.<sup>14</sup> Occasionally, valuable information is obtained from a plain röntgenogram demonstrating calcification of the vessels, but this gives no indication of the patency of the lumen. The circulation in the arterioles and sub-papillary network of vessels may be judged by the appearance of the part, its temperature, its reaction to elevation or dependency, by the return of the color after blanching, by the absorption of intradermal saline or histamine, by the Moschowitz test or other similar tests. Any one or all of these methods may give valuable information of an indirect nature and some of them should always be included in the routine physical examination of patients with these disorders. For the most part, the methods of physical examination by a competent observer will serve, without the use of special

## VISUALIZATION ARTERIES OF EXTREMITIES

tests, to distinguish between the cases of mild and severe arterial obliteration. But in many instances no such definite differentiation can be made and even with the use of all available tests there remains a legitimate doubt of the extent of the damage.

The direct visualization of the arterial tree with the main trunk, the branches and the arterioles is of inestimable value. If the site and the extent of the involvement are known, appropriate therapy may be advocated. Useless amputation may be avoided, or, if amputation is indicated, it may be advised with the conviction of its necessity and the exact level determined to assure vascularity of the stump.

Since the desirability of arterial visualization is so obvious, it is not surprising that many investigators have sought to perfect a method for its use. Moniz,<sup>12</sup> Harvier and Lemaire,<sup>10</sup> Brooks,<sup>2</sup> Singleton,<sup>17</sup> Carnett and Greenbaum,<sup>6</sup> Saito, *et al.*,<sup>15</sup> and others,<sup>1, 4, 5, 7, 8, 9, 11, 16</sup> have reported on arteriography. In general, sodium iodide or iodized oils have been the opaque media selected. It has been found that these substances possess disadvantages. Sodium iodide in the concentration used has resulted in damage to the vessels with increase in pain and gangrene, in symptoms of poisoning, and in death. The iodized oils, on the other hand, all have the common fault that the injection of any fatty substances into the blood-stream may lead to fat embolism with serious consequences and even death. Some authors have not stressed these results even when deaths have occurred in their cases. With the deleterious results following the use of these two substances, it is apparent why arteriography has never gained wide acceptance. But there is every reason to advocate the procedure as a diagnostic method. The fault has been with the opaque media used for the purpose. Consequently, we have been on the alert to find a medium which would give sufficient contrast to outline the vessels but which would have no deleterious local or general effects.

Many substances, including "uroselectan," have been tried out on animals in this laboratory without success until sodium-monoiodo-methane sulphate (methiodol) was found to be a satisfactory material for the purpose. These laboratory studies will be published elsewhere. With the production of sodium-monoiodo-methane sulphate\* for intravenous pyelography, a compound was available for arterial visualization that fulfilled the necessary requirements, namely:

- (1) The drug has already had a wide clinical use for intravenous pyelography and its safety with a dose of forty grams has been demonstrated. Only twenty grams or less in a 40 per cent. solution are required for arteriography, so that the fear of a general deleterious effect is eliminated.

- (2) The solution in the concentration used is sufficiently radio-opaque to give sharp definition of the vessels.

- (3) Experiments on animals and clinical trials revealed no deleterious

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\* Marketed as "skiodan" by the Winthrop Chemical Company.



effect even on the damaged vessel walls. Evidence of thrombosis was never found.

*Animal Experiments.*—Before methiodol was injected into patients with vascular disease it was necessary to prove its compatibility with the vessel endothelium and so somewhat higher concentrations were used than is necessary to produce good arteriograms.

Eight experiments were done on dogs. These were designed to determine if possible whether the drug caused irritation of the wall of the artery. A 40 per cent. solution of methiodol produced satisfactory arteriograms while a 50 per cent. solution was used in all of these experiments to intensify any deleterious effects upon the blood-vessel endothelium. There is, of course, the criticism that the normal vessel may withstand greater concentrations than the diseased but clinical trial has so far been innocuous in our hands.

The following experiments were done: (a) The solution was injected continuously for five minutes into the artery; (b) a segment of artery was isolated, the blood expressed from it, and a loop excluded by rubber-shod clamps. This closed segment was filled with the solution for from one to five minutes before the clamps were removed and the circulation through the segment reestablished. In this way it was felt that the maximum concentration was in contact with the vessel wall for as long as would ever occur in clinical use.

At the end of twenty-four hours and forty-eight hours, the specimens were examined, and sections were taken for histologic study. In no case was there gross or microscopic evidence of thrombosis or injury to the intima.

*Clinical Cases.*—Encouraged by the lack of any harmful local action on the vessel wall in the experiments on dogs, it was decided to use the drug in clinical cases of obliterative vascular disease. The drug is dissolved in fresh, glass distilled water, carefully filtered and sterilized by boiling. At first a 50 per cent. solution was used but it was later found that a 40 per cent. solution was satisfactory and even lower concentrations will serve. The operative method is as follows: Without using a tourniquet, the femoral artery is exposed in Hunter's canal and is separated from the femoral vein and nerve. The casset containing the film is placed beneath the leg under the drapes and the Röntgen tube centred over the area to be studied. The artery is picked up on a tape and compressed between the thumb and finger to prevent admixture of the solution with blood. The vessel wall is punctured obliquely with a new, sharp, No. 20 gauge needle to which is attached a fifty cubic centimetre syringe containing the methiodol solution. Injection is begun and after about twenty-five cubic centimetres of methiodol have been injected the film is exposed while the solution is still being forced into the artery. The injection is stopped without removing the needle while the film is changed. Then after injecting an additional twenty-five cubic centimetres, the second exposure is obtained while the last five cubic centimetres of the solution are being forced into the artery. After withdrawing the needle the pressure on the artery is released and a moment's pressure with a

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sponge stops all bleeding. The elapsed time from the beginning to the end of the injection should be ninety seconds or less. This is a very important part of the technical procedure. There is a remarkable absence of bleeding with the arterial puncture done in this manner. One patient with a systolic blood-pressure of 280 millimetres of mercury was operated upon and not more than three or four drops of blood escaped from the puncture wound.



FIG. 1.

FIG. 1.—Case I. All of the major arteries have been occluded and the circulation is being carried on by collateral channels. The arrow points to an anastomotic loop which fills the lower part of the posterior tibial artery.



FIG. 2.

FIG. 2.—Case IV. An arterial injection showing patent main vessels in the leg. The arrows point to the well-filled dorsalis pedis and posterior tibial arteries.

In all, eight cases were operated upon. In one instance the femoral artery was so sclerosed that very little of the solution could be injected so that this case was excluded. A brief résumé of the remaining seven cases is given:

### CASE REPORTS

CASE I.—F. F., No. 44,975. The patient was a seventy-three-year-old woman, a diabetic of eight years' standing who entered the clinic with diabetic gangrene of the right foot. The peripheral arteries were pulseless, the foot was cold and cyanotic and

there was pallor with elevation and rubor with dependency. The gangrenous areas extended from the first and fifth toes up on to the lateral margins of the foot.

The day after admission, under spinal anaesthesia, the femoral artery was injected with seventy cubic centimetres of 50 per cent. methiodol solution. The röntgenograms shown in Fig. 1 revealed marked impairment of the arterial circulation. A low thigh amputation was done and the patient had an uneventful convalescence.

CASE II.—M. A., No. 45,369. The patient was a sixty-year-old woman, a diabetic, who has had symptoms of vascular insufficiency in the right leg and who developed an ulcer on the right foot seven weeks ago. Four weeks before admission a peri-arterial sympathectomy was done in another hospital without relief of symptoms.

For the past eight years she has known that she had hypertension (systolic blood-pressure ranges from 200 to 280 millimetres of mercury) and two years ago she had a transient hemiplegia. On examination the foot was cold, pulseless, and discolored, with a shiny skin. There was marked muscle atrophy, the nails were hypertrophied, and the color of the foot was markedly changed by a shift in position. There was gangrene of the third and fourth toes involving the web space and extending on to the dorsum of the foot.

Under general anaesthesia the femoral artery was injected with sixty cubic centimetres of 50 per cent. methiodol. The films showed that all of the major vessels were obliterated and only a few of the smaller collaterals remain. A mid-thigh amputation was done and aside from delayed healing of the stump, the convalescence was uneventful.

CASE III.—W. B., No. 33,460. The patient, a seventy-one-year-old man, a diabetic, had a Gritti-Stokes amputation of the right leg for diabetic gangrene a year before the present admission. He now entered the clinic complaining of a cold, painful, discolored left foot. Examination revealed the foot to be a red'dish plum color with pigmentation of the skin of the calf. The muscles were atrophic, the skin was dry and glistening, the nails were hypertrophied, the skin was colder than normal and the dorsalis pedis and posterior tibial arteries did not pulsate. The popliteal pulsation was felt and the recording sphygmomanometer showed a normal popliteal pulse.

Under local infiltration anaesthesia, the popliteal artery was exposed and thirty cubic centimetres of 50 per cent. methiodol injected. The artery was so deep in the wound that a right-angle needle designed for peritonsillar infiltration had to be used. During the course of the injection the patient complained of cramps in the leg which ceased as soon as the injection was discontinued. This was thought to be due to the hypertonicity of the solution.

The röntgenograms revealed only moderate involvement of the arterial tree and a popliteal vein ligation was decided upon and performed.

After operation the color and temperature of the foot improved and pain ceased. At the time of discharge, his condition, to use his own words, "was a lot better." There was no evidence of a harmful effect of the arteriogram and a follow-up examination six weeks after operation revealed continued improvement.

CASE IV.—A. R., No. 46,568. The patient was a forty-year-old woman, a diabetic who entered the hospital with gangrene of the foot of two weeks' duration. Examination revealed a toxic, sick woman with gangrene of the first toe and medial side of the foot. There was sclerosis of the peripheral vessels with marked swelling and oedema of the foot and lower calf. The discharge from the affected area was very foul and gas bubbles were demonstrated by röntgenograms.

Immediate operation was done under spinal anaesthesia. The femoral artery was exposed in Hunter's canal and injected with thirty cubic centimetres of 50 per cent. solution of methiodol. The leg was amputated through the mid-thigh and the wound left open. Convalescence was uneventful. The wound closed by second intention and the bone was covered by drawing down the flaps with skin traction.

The arteriogram (Fig. 2) showed the main vessels and collateral channels to be

## VISUALIZATION ARTERIES OF EXTREMITIES

patent down to the level of the ankle. Amputation might have been avoided if the patient had been seen earlier, before gas-bacillus infection had occurred.

CASE V.—B. McS., No. 46,563. This case was a sixty-two-year-old male who was admitted with the complaint of chronic ulcers on the foot of nine months' duration. A few days prior to admission gangrene of the great toe developed. The foot was blue, cold and pulseless. There were foul-smelling indolent ulcers over the heads of the first and fifth metatarsals and early gangrene of the great toe was apparent. The urine was sugar-free and the blood-sugar level was normal, so the lesion was considered to be on an arteriosclerotic basis.

Under spinal anaesthesia, the femoral artery was injected with thirty cubic centimetres of 50 per cent. methiodol. The arteriogram showed in Fig. 3 slight involvement of the major arteries and obliteration of many of the collaterals. A mid-thigh amputation was done. The patient had a slow convalescence from poor healing of the stump.

CASE VI.—L. M., No. 46,106. The patient, a woman of sixty years, entered the hospital with symptoms of myocardial failure of six months' duration. Two days before

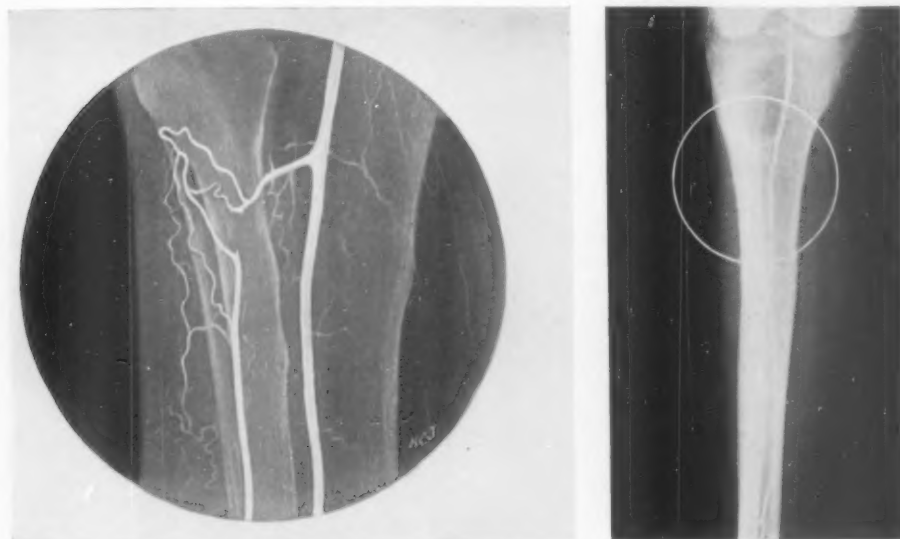


FIG. 3.—Case V. The arteriogram shows a normal popliteal and upper posterior tibial arteries. The anterior tibial is obliterated at its origin. So much of the detail of these films is lost by reproduction that a drawing was made of an actual tracing to show the anastomotic loops like a "Medusa head") around the point of obliteration of the anterior tibial artery.

admission she began having pain in the right leg. Examination revealed the classical symptoms and signs of rheumatic heart disease with mitral stenosis and auricular fibrillation. The right leg was cold, blue, pulseless and tender. There was beginning gangrene between the third and fourth toes. The popliteal pulse was perceptible. A diagnosis of embolism of the lower part of the popliteal artery was made. Too great an interval had elapsed for embolectomy.

Under ether anaesthesia the femoral artery was injected with forty cubic centimetres of 50 per cent. methiodol solution. Photographs of the roentgenograms are shown in Fig. 4. The filling of the collateral branches is well shown. A drawing of the embolus is shown in Fig. 5. A low thigh amputation was done; the patient made an uneventful recovery.

CASE VII.—M. E., No. 47,302. The patient was a sixty-seven-year-old woman, a diabetic, who entered the clinic with gangrene of the third toe, left, which originated from an infection of two weeks' duration. Examination showed gangrene of the third toe with involvement of the base of the second and fourth toes with œdema of the foot



FIG. 6.



FIG. 5.



FIG. 4.

FIG. 4.—Case VI. The popliteal and posterior tibial arteries are obstructed. The anterior artery is occluded at its origin, but is filled by the anterior tibial recurrent artery which connects it with the cruciate anastomosis about the knee-joint (arrow 1). Arrow 2 points to a long anastomotic branch from the femoral artery which fills the posterior tibial at the level of the ankle.

FIG. 5.—The location of the embolus in the popliteal artery in Case VI.

FIG. 6.—Case VII. The arrow points to the obliterated posterior tibial artery. The dorsalis pedis and other smaller vessels are well filled.



## VISUALIZATION ARTERIES OF EXTREMITIES

and signs of a sub-plantar fascial abscess. The dorsalis pedis pulse was present but that of the posterior tibial was absent; however, the clinical impression was that the circulation was adequate.

Under spinal anaesthesia the femoral artery was injected with thirty-five cubic centimetres of a 40 per cent. methiodol solution. It will be seen from Fig. 6 that this concentration was sufficiently radio-opaque to give a good arteriogram and the films reveal that the clinical impression of the circulation was confirmed.

The second, third and fourth toes were amputated and the sub-plantar fascial abscess was drained. The patient made a good recovery from the operation and there was no indication that the arterial injection did harm to the peripheral vessels of the leg.

**DISCUSSION.**—In two instances, amputation was not done after the injection and there was no indication of a detrimental effect from the arteriogram. In the remaining five amputated cases, dissection of the vessels revealed no damage to the intima or thrombosis resulting from the injection. In one case the popliteal artery was injected. This is not recommended for the deep wound prevents easy injection and might well embarrass the surgeon in case of hæmorrhage. The exposure of the femoral artery in Hunter's canal is easier, permits of more accurate injection and allows the surgeon to retain command of the situation under any circumstances.

The cases presented have all been instances of obliterative arterial disease. It is conceivable that the method could be used to demonstrate many other pathologic processes. Among these may be mentioned aneurism, arterio-venous communications, deep phlebitis, the state of the perforating branches of varicose veins and the demonstration of tumors. In fact, work has already been done in this clinic using the method for cerebral arteriography in cases of brain tumor. The future will decide the indications for use of the method in other conditions but if it is restricted to the obliterative arterial diseases alone, this should be of sufficient value to justify it.

### SUMMARY

(1) A method of arteriography using sodium-monoiodo-methane sulphate (methiodol) has been proposed. This substance in a 40 per cent. solution is sufficiently radio-opaque to give good definition of the vessels of the leg. No local or general harmful effect from the intra-arterial injection of this substance has been noted in our cases.

(2) The experience with animal experiments and with seven cases of obliterative arterial disease of the extremities is reported.

(3) Illustrations are given of the accurate definition of the site and the amount of arterial obstruction in cases of obliterative vascular disease.

### BIBLIOGRAPHY

- <sup>1</sup> Berberich, and Hirsch: Roentgenographische Darstellung der Arterien und Vene am lebenden mensch. *Klin. Wchschr.*, vol. ii, p. 2226, 1923.
- <sup>2</sup> Brooks, B.: Intra-arterial Injection of Sodium Iodide. *J. A. M. A.*, vol. lxxxii, p. 1016, 1924.
- <sup>3</sup> Brown, G. E.: The Treatment of Peripheral Vascular Disturbances of the Extremities. *J. A. M. A.*, vol. lxxxvii, p. 379, 1926.

PEARSE, JR., AND WARREN

- <sup>4</sup> Charbonnel, and Masse: Arteriographie des Membres avec l'Iodure de Sodium Spécialement dans les arterites. Bull. et Mem. Soc. Nat. de Chir., vol. lv, p. 735, 1929.
- <sup>5</sup> Coapody, J.: Arterienphotographien Vermittels, Lipiodal. Klin. Wchnschr., vol. iv, p. 2327, 1925.
- <sup>6</sup> Carnett, J. B., and Greenbaum, S. S.: Blood-vessel Visualization. J. A. M. A., vol. lxxxix, p. 2039, 1927.
- <sup>7</sup> Desplats, Desbonnet, Buisson, and Delcour: Le Lipio-diagnostic arteriel. Jour. des Sc. Med. de Lille, vol. xlv, p. 40, 1926.
- <sup>8</sup> Forestier, J.: L'Huile Iodie en Pratique Radiologique. Paris Med., vol. li, p. 377, 1924.
- <sup>9</sup> Frazier, C. H.: The Use of Iodized Rape-seed Oil (Campiodel) for Röntgenographic Exploration. ANNALS OF SURGERY, vol. lxxxix, p. 801, 1929.
- <sup>10</sup> Harvier, P., and Lemaire, A.: Renseignements Fournis par L'Exploration Lipiodolee dans les Arterites des Membres Inferieurs. Bull. et Mem. Soc. Med. d Hosp. Paris, vol. li, p. 448, 1927.
- <sup>11</sup> Leibovici, R.: L'arteriographie dans les gangrenes des membres inferieurs. Jour. de Chir., vol. xxxiv, p. 293, 1929.
- <sup>12</sup> Moniz, E.: Nouvelle Technique de L'Encephalographie Arterielle. La Presse Med., vol. xxxvi, p. 689, 1928.
- <sup>13</sup> Morton, J. J., and Scott, W. J. Merle: (a) The Measurement of Sympathetic Vasoconstrictor Activity in the Lower Extremities. Jour. Clin. Investig., vol. ix, p. 233, 1930; (b) Obliteration of Vasoconstrictor Gradient in the Extremities under Nitrous-Oxide-Oxygen, Ether and Tribromethyl Alcohol Anæsthesias. Proc. Soc. Exp. Biol. and Med., vol. xxvii, p. 945, 1930; (c) Methods for Estimating the Degree of Sympathetic Vasoconstriction in Peripheral Vascular Diseases. New Eng. Jour. of Med., vol. cciv, p. 955, 1931.
- <sup>14</sup> Pearse, H. E., Jr., and Morton, J. J.: The Blood-pressure in the Arteries of the Extremities in Normal Subjects and in Patients with Peripheral Vascular Disease. Am. Jour. Med. Sc. (in press).
- <sup>15</sup> Saito, M., Kamikawa, K., Yanagizawa, H.: A New Method of Blood-vessel Visualization *in Vivo*. Am. Jour. Surg., vol. x, p. 224, 1930.
- <sup>16</sup> Sicard, de Gennes, and Caste: Radio-Diagnostic Lipiodole de la Thrombose Arterielle. Soc. Med. des Hopit. de Paris, vol. xlviii, p. 1483, 1924.
- <sup>17</sup> Singleton, A. O.: Use of Intra-arterial Injections of Sodium Iodide in Determining Condition of Circulation in the Extremities. Arch. Surg., vol. xvi, p. 1234, 1928.
- <sup>18</sup> White, J. C.: Diagnostic Blocking of Sympathetic Nerves to Extremities with Procaine. J. A. M. A., vol. xciv, p. 1382, 1930.

## GANGRENE OF THE FINGER FOLLOWING DIGITAL NERVE BLOCK ANÆSTHESIA

BY JOHN H. GARLOCK, M.D.

OF NEW YORK, N. Y.

FROM THE SECOND SURGICAL DIVISION OF THE NEW YORK HOSPITAL

DURING the past two years I have seen four cases of such unusual interest and importance as to warrant recording them in surgical literature. These four patients presented almost identical histories, clinical course, treatment, and complications, thereby practically eliminating the element of chance in the occurrence of the unfortunate end-result in each instance.

All text-books on general surgery and anæsthesia and the special monographs on the hand speak of the ease with which operations may be done on the distal half of the finger with the aid of digital nerve block anæsthesia. The usual description of this procedure includes proper sterilization of the finger and hand, the application of a tight tourniquet (catheter or rubber band) about the base of the finger and the injection of .5 per cent. or 1 per cent. freshly prepared novocaine solution on the lateral aspects of the finger just beyond the tourniquet so as to infiltrate the digital nerves and the tissues surrounding them. The reason given for the use of the tourniquet is that it prevents rapid absorption of the novocaine solution by lymphatics, thereby prolonging the period of anæsthesia which, under ordinary circumstances, varies from twenty minutes to one and one-half hours. Following completion of the operation, the tourniquet is removed and sensation returns soon after.

I venture to say that this procedure is executed daily hundreds of times the world over. That it is not without danger and presents serious drawbacks as it is ordinarily carried out, is evidenced by the fact that each of the following four cases, twenty-four to forty-eight hours later, developed a dry gangrene of the finger distal to the point of injection of the novocaine, necessitating amputation. As far as I am able to determine, this complication has not been described before.

### CASE REPORTS

CASE I.—M. L., male, aged forty-three years, was referred by Dr. C. H. Fornell fifteen days after the receipt of an injury to the left thumb. On March 11, 1930, a piece of a needle from a sewing machine entered the left thumb, lodging in the nail bed at about the level of the lunula. On the following day, he consulted a physician who, after placing a rubber band tourniquet tightly about the base of the thumb and injecting novocaine solution on the dorsum distal to this point, removed the needle. The tourniquet was removed after a half hour. Two days later, a bluish discoloration of the end of the thumb was first noted. This gradually became more pronounced until a bluish-black hue was noted. A definite line of demarcation developed at about the level of the interphalangeal joint. Three or four days later the patient began to experience severe pain.

When I saw the patient, he presented a well-defined dry gangrene of the left thumb with an irregular clear-cut line of demarcation at the level of the interphalangeal joint. (Fig. 1.) There was no sensation in the gangrenous area and needle puncture drew no blood. There was an area of marked hyperæsthesia just proximal to the line of demarcation, but there was no evidence of infection. X-ray examination was negative, as were also urinalysis, blood sugar, and Wassermann. Partial amputation of the thumb was advised, but the patient persistently refused to have this done. A spontaneous amputation resulted by the end of August, 1930. Since then the patient has been well.

CASE II.—Miss J. P., aged twenty-nine years, was referred by Dr. M. L. Pinco eleven days after the original injury. On February 9, 1931, she accidentally stuck a pin into the right middle finger near the paronychia tissue on the outer side. On the following day, severe pain was experienced and she consulted a physician who stated that infection was present and advised incision. After placing a rubber-band tourniquet tightly about the base of the finger, he obtained digital nerve block anæsthesia with 1 per cent. novocaine injected on both sides. A small incision was made and a drop or two of pus was obtained. The tourniquet was removed after fifteen minutes. On the following day it

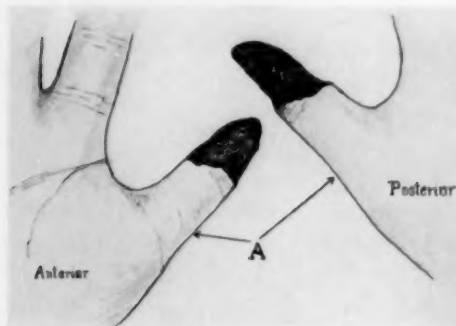


FIG. 1.

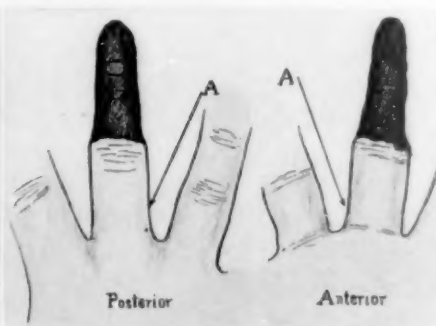


FIG. 2.

FIG. 1.—Sketch of condition found in Case I, showing the well-defined line of demarcation. "A" indicates the approximate site of application of tourniquet.

FIG. 2.—Case II. The well-defined line of demarcation is indicated. "A" marks the site of application of tourniquet.

was noted that the distal half of the finger was blue and cold. The color became progressively darker during the next few days and the part was anæsthetic.

Examination eleven days after the injury showed a symmetrical dry gangrene of the right middle finger with a clear-cut line of demarcation about one-quarter of an inch distal to the proximal interphalangeal joint. (Fig. 2.) The gangrenous area was completely anæsthetic and needle puncture drew no blood. All the laboratory examinations were negative.

On February 21, 1931, the finger was amputated at the proximal interphalangeal joint. The wound was left wide open. Healing took place by granulation and was complete by March 28, 1931. She has remained well.

Pathological examination of the amputated finger showed thrombosis of the digital vessels. The thrombi were apparently well organized. The nuclei of the connective tissue cells were very indistinct. (Fig. 3.)

CASE III.—W. K., aged twenty-nine years, was first seen two weeks after a splinter of wood entered the pulp of the right index finger at its tip. An anterior closed space infection apparently developed which was treated with wet dressings for two days, followed by incision without anæsthesia at a hospital. As the pain was not relieved, the patient consulted a physician who, after placing a small catheter tightly about the base of the finger, obtained nerve block anæsthesia with 1 per cent. novocaine solution by lateral injections. An incision was then made. The part was then soaked in warm

## POST NERVE BLOCK DIGITAL GANGRENE

Epsom salts solution. On the following day the dorsum of the finger distal to the distal crease was blue, while the anterior aspect appeared dead white. By the fifth day the end of the finger was black and malodorous.

Examination two weeks after the original injury showed a symmetrical gangrene at the end of the right index finger with gangrenous necrosis of the skin and subcu-

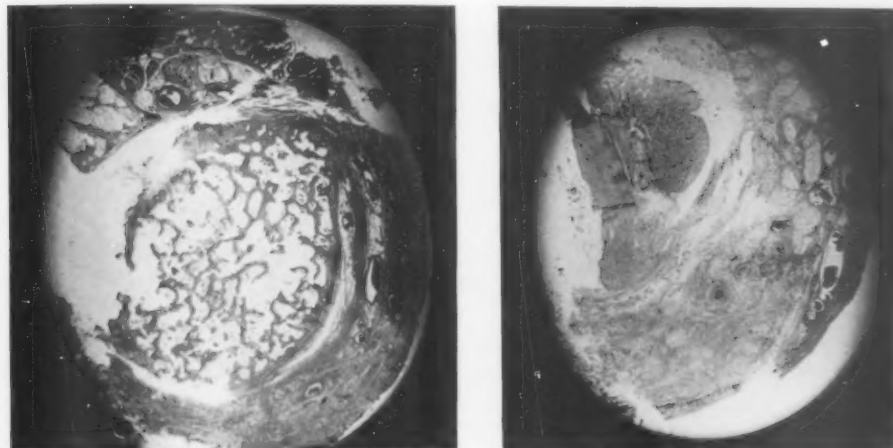


FIG. 3.—Case II. Microscopical section of amputated finger taken transversely through the level of the nail base. Section made after decalcification. The organized thrombi in the digital blood-vessels are visualized.

taneous tissues on the dorsum of the entire finger. (Fig. 4.) The line of demarcation anteriorly was at the distal flexion crease. The whole finger was exquisitely tender due to infection beneath the gangrenous skin on the dorsum. All laboratory examinations were negative. Partial amputation was advised and carried out through the centre of

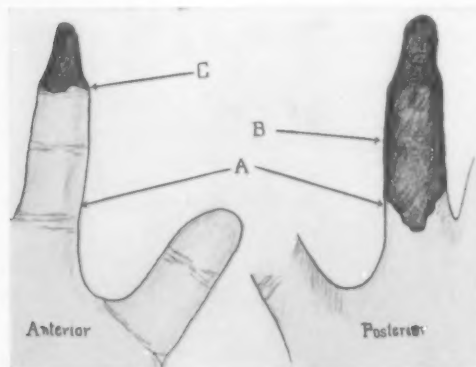


FIG. 4.

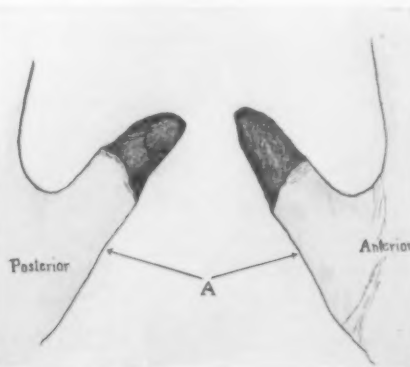


FIG. 5.

FIG. 4.—Appearance of finger on first examination in Case III. "A" indicates the site of application of tourniquet. "B" represents the area of gangrenous skin on the dorsum. "C" represents the line of demarcation anteriorly at the level of the distal flexion crease.

FIG. 5.—Diagrammatic sketch of condition found in Case IV, showing the well-defined line of demarcation on all aspects of the thumb. "A" represents the exact site of application of the tourniquet.

the middle phalanx. The necrotic skin on the dorsum was excised. Healing took place by granulation without incident. The amputated finger was too necrotic for satisfactory microscopical section.

CASE IV.—L. L., aged twenty-two years, was seen in consultation with his physician on January 10, 1931. Four days before, a piece of needle accidentally entered the pulp



of the left thumb. The patient immediately went to his doctor who, after much difficulty, removed the foreign body. The operation apparently was performed under strict aseptic precautions. After skin sterilization, a small rubber catheter was placed snugly about the base of the thumb. Digital nerve block anaesthesia was obtained by injecting freshly prepared 1 per cent. novocaine solution laterally. About 6 cubic centimetres of this solution were used before anaesthesia was complete. The operation lasted a little over an hour. Upon removal of the tourniquet, bleeding was moderate. That night, the pain was very severe. On the following day, the end of the thumb was dark blue and anaesthetic.

Three days later examination showed a symmetrical dry gangrene of the end of the left thumb with a well-defined line of demarcation at the distal flexion crease. (Fig. 5.) There was no evidence of infection. General physical examination was negative. Urinalysis, blood examinations and X-ray were negative. Partial amputation was advised and was carried out by the attending physician. Healing took place without incident. Unfortunately, the amputated finger was not preserved.

*Discussion.*—It is of interest to speculate as to the exact mechanism behind this unusual occurrence. Each patient was a young adult and presented nothing abnormal on general examination. There was no evidence of arterial disease and all laboratory studies were negative. It would seem, therefore, that the cause was a local one. When the first case was seen, it was thought that, possibly, the novocaine solution had been injected directly into the digital vessels, causing thrombosis. Subsequently, this was considered highly improbable. In no instance was an occlusive dressing used after operation, nor was a carbolic salve applied. In each case, wet dressings of saline, boric or magnesium sulphate solution were used and these were not unusually hot.

It will be remembered from the case reports that the attending physician placed a rubber-band or catheter tourniquet *tightly* about the base of the finger before injecting the anaesthetic solution. This would produce two effects, marked local slowing of the blood-stream and local pressure injury to all tissues included in the constricting effect of the tourniquet. I believe that the question of the sterility of the novocaine solution can be answered by the absence of subsequent infection at the site of injection. However, it is probable that the mechanical presence of the solution in the tissues just distal to the point of constriction of the tourniquet was an added factor in the development of the gangrene. Individual idiosyncrasy to novocaine might be considered as a possible etiological factor. However, three of the patients had had previous experiences with novocaine anaesthesia, with no unusual or untoward effects.

After consideration of all the facts, it would seem reasonable to assume that the mechanism of production of the gangrene was as follows: The tight application of a thin tourniquet caused marked local slowing of the blood-stream and tissue injury included in its constricting effect. The latter caused injury to the endothelial lining of the digital vessels, thus favoring thrombosis. The injection of a solution distal to this point constituted an additional mechanical insult, further favoring thrombosis. That all the digital vessels were not involved in each instance is evidenced by the fact that, in

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two cases, the gangrene was not symmetrical and presented an irregular line of demarcation. Microscopical section of one of the amputated fingers showed definite thrombosis of the digital arteries.

I believe a real lesson is to be learned from these four cases. In the first place, it is distinctly hazardous to use a tourniquet of narrow calibre because the local tissue injury is more centralized. A broad application is safer. Secondly, for the usual incision and drainage, it is unnecessary to occlude the arterial supply by tightening the tourniquet as far as it can be pulled. The purpose of the tourniquet is to prevent rapid absorption of the anæsthetic agent and not to obtain a bloodless field. If the latter is necessary, as in looking for foreign bodies, a properly applied Esmarch bandage is more effective and certainly safer. If these facts are remembered and if the necessary precautions are taken, the complication described in this communication should never occur.

### CONCLUSIONS

(1) Four cases of gangrene of the finger following digital nerve block anæsthesia are described.

(2) After careful consideration of all the available facts, the cause for this complication is undoubtedly a local one.

(3) The essential factor is a thrombosis of the digital vessels produced by the tight application of a narrow tourniquet which causes local tissue injury and marked slowing of the blood-stream. An added factor may be the mechanical presence of the anæsthetic agent distal to the point of constriction of the tourniquet.

(4) The prevention of complications of a similar nature rests with the care with which a tourniquet is applied about the base of a finger. A tourniquet of narrow calibre should be avoided and, for ordinary purposes, occlusion of the arterial supply is contra-indicated.

(5) When a bloodless field is desired, a properly applied Esmarch bandage is more effective and safer.

# TRANSACTIONS

OF THE

## NEW YORK SURGICAL SOCIETY

STATED MEETING HELD MAY 13, 1931

### ABDOMINAL HODGKIN'S DISEASE WITH INTESTINAL OBSTRUCTION

DR. ALFRED STILLMAN presented a woman, forty-three years of age, who had been suffering for five years with attacks of nausea, vomiting and distention; at first apparently from injudicious eating, but gradually increasing in frequency. Two years ago she had an operation for hæmorrhoids. Eight months before admission to Roosevelt Hospital she had been to St. Lukes. Here a Wassermann was 1 plus. She came to Roosevelt Hospital because for five days she had been unable to retain anything on her stomach. She has lost fifty pounds in weight in seven months.

*Physical Examination.*—Showed peristaltic waves in lower abdomen. No masses could be felt nor the liver or spleen. Laboratory findings were: Hæmoglobin, 84; red blood-cells, 4,600,000; white blood-cells, 4,900 with 76 per cent. polymorphonuclears and 24 per cent. lymphocytes. Blood-pressure, 114/30. No free hydrochloric acid in gastric test meal. X-ray of chest was normal. X-ray of the intestines showed considerable dilatation of numerous coils of small bowel, suggesting an obstruction of the small bowel. Urine showed sugar twice and red blood-cells twice.

At operation, November 13, 1930, a quantity of clear straw-colored fluid was aspirated from the abdominal cavity and this cultured later a staphylococcus albus. In the small intestinal wall, some few feet from the ileo-cæcal valve, there were several small, whitish masses two to three centimetres in diameter and umbilicated. In the mesentery of these loops was a matted mass of glands very firm in consistency and discolored as by hæmorrhage. The small gut above was dilated and hypertrophied and that below was normal.

One gland was removed for diagnosis. An enteroenterostomy was done between a loop above and one below the obstruction. This operation gave considerable relief but now, six months afterwards, she is again suffering from obstruction. She was presented because the retroperitoneal type of Hodgkin's disease is rare, and obstruction also is not common. The pathologic report was Hodgkin's disease.

### CHOLECYSTENTEROSTOMY FOR OBSTRUCTIVE JAUNDICE

DOCTOR STILLMAN presented a woman, forty-one years of age, who had been suffering from jaundice for five and one-half weeks. She was unable to keep anything on her stomach. The vomitus consisted of gastric contents and no bile. The stools were clay-colored and the urine dark. She complained only of occasional throbbing pain in her right side near the costal margin. She had lost some weight. The liver was not tender, was smooth, and its edge felt three inches below costal margin. Phthalein dye failed to show the outline of the gall-bladder and did not identify gall-stones.

At operation, November 27, 1929, the common duct was found dilated but the gall-bladder contained no palpable stones. A probe passed into an

## CHOLECYSTENTEROSTOMY FOR OBSTRUCTIVE JAUNDICE

opening made in the common duct seemed to stop at the papilla of Vater. The duodenum was opened opposite the end of the probe, which was then lifted to bring the papilla better into view. The probe entered the duodenum but it was not certain that it did not make a new opening to do so. The cause of the obstruction was not determined so an anastomosis was made between the duodenum and gall-bladder, using the incised wound already made in the duodenum.

Post-operatively, she was given calcium chloride for oozing. On December 2, hemorrhage from the wound was alarming. Some sutures were removed and a bleeder located and ligated. Up to December 9 clots were removed from wound at dressings. December 16 the common-duct tube was removed. On the forty-third day bile stopped draining and the stools became brown.

Since her discharge about every two weeks she has had pain in the gall-bladder region, chills and fever. Otherwise she feels well and her weight remains normal. The question in this case is whether a stone has been missed or is it a case of infection through the anastomosis?

DR. HENRY W. CAVE remarked that patients often had chills, fever and pain in the right upper quadrant when a stone has been left behind or has re-formed, or there has been an infection by way of the anastomosis. A few years ago surgeons were divided as to which was the best procedure—cholecystduodenostomy or cholecystgastrostomy. In that connection, he discussed a case in whom a choledchoenterostomy was done with a Murphy button. The patient made a satisfactory convalescence and had an excellent late result. He was a man sixty-eight years of age who, in August, 1927, had pain in the right upper quadrant accompanied by elevation of temperature. He was admitted to the Roosevelt Hospital; after three days' observation the gall-bladder was removed. It contained a large stone. The wound was drained from the upper angle. He continued to drain and lost about seventy pounds in weight, apparently through the persistent biliary fistula. At the time of the operation the common bile-duct had been examined, but no stones found. One hundred nine days after the choledchoenterostomy he re-entered the hospital with clay-colored stools and a persistent biliary fistula. He was again operated upon and an attempt made to shunt this persistent fistula into the stomach. It was then thought there was an obstruction in the lower part of the common bile-duct. The common bile-duct proximal to this obstruction was markedly dilated. Adhesions were quite dense at the lower end of the common bile-duct, so that it was impossible to tell definitely whether a stone was present in the papilla of Vater. A Murphy button was first placed in the common bile-duct and anastomosed to the duodenum. This button was passed on the ninth day post-operative. The wound healed primarily. He was discharged after three weeks. He made a very uneventful recovery. Three months later he had gained fifty-eight pounds in weight. He has remained well since. The use of the Murphy button was advantageous particularly in this case, as it was a much quicker procedure than doing a suture operation. Some time had been wasted in trying to dissect out the original biliary fistulous tract and in a patient his age he was

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not in too good a condition. As far as Doctor Cave knew, this was the only instance where a Murphy button had been used to do a choledochoduodenostomy.

DR. FREDERIC W. BANCROFT said that in doing a cholecystgastrostomy the use of the Murphy button provides a most satisfactory means of doing anastomosis in those cases where it is advantageous in the first forty-eight hours to have a discharge of bile. In bleeding cases, also, it may prevent bleeding around the sutures.

DR. WINFIELD SCOTT SCHLEY referred to a case he had ten years ago at St. Lukes Hospital of a woman with marked obstructive jaundice in which exploration showed a small, hard pancreas. The duodenum was near and an anastomosis was made between the gall-bladder and the duodenum. The anastomosis was quickly done using a small button with reinforced gut suture. She passed the button two years later after a sharp attack of pain in upper abdomen. Seven years later she was admitted to the emergency ward with an acute, gangrenous pancreatitis, from which she died. It is surprising that such a small, hard, contracted pancreas could (actively) function for such a length of time, and interesting that she should subsequently develop an acute pancreatitis, causing death. She was apparently in excellent health on her visits to the follow-up clinic during these intervening years. Jaundice had entirely cleared following her operation.

DR. JOHN DOUGLAS called attention to the sedimentation time instead of the bleeding time in the blood in cases of obstructive jaundice. He said that a disadvantage in the use of the Murphy button was that it might fall into the gall-bladder and the patient subsequently have more pain because of this. This happened in one case of his and there was severe hæmorrhage and the patient died as a result of a second operation. While the Murphy button is expected to go into the stomach, it can fall back into the gall-bladder. Doctor Douglas had one case in which the patient had an abscess between the gall-bladder and the duodenum and came back with severe jaundice after cholecystectomy. It was subsequently necessary to do a lateral anastomosis by the suture method between the common duct and duodenum. If there is a large dilated duct there is no difficulty in making the anastomosis between the duodenum and the common duct. In regard to the question of dissecting out the sinus and inserting it into the stomach, one should never try to dissect the sinus beyond the liver margin, for if one tries to dissect it away from the edge of the liver one always gets into the sinus.

DOCTOR STILLMAN rejoined that, so far as he knew, the sedimentation test was not used at the Roosevelt Hospital. The clotting and bleeding time of jaundice cases are taken and when these are prolonged calcium chloride is given. In the case under discussion anastomosis to the stomach seemed simpler because of the deep position of the duodenum. It was done by the ordinary suture method. In those cases where severe bleeding is



## HEMANGIOMA OF THE ERECTOR SPINÆ MUSCLE

feared the Murphy button may be useful. As to whether there is more chance of infection extending to the liver when the anastomosis is made in the stomach or the duodenum, the speaker thought there was little difference and anastomosed that viscus which was easiest to bring up. At the first operation there was no stone seen or felt.

## HEMANGIOMA OF THE ERECTOR SPINÆ MUSCLE

DR. EDWARD D. TRUESDELL presented a woman, thirty years of age, who had suffered from backache for five years or more. The pain had been particularly troublesome at night, tending to wear away during the day-time. Pain was situated in the middle and lower part of the back and was never associated with any other symptom. Upon inspection there was a slight prominence of the region just to the left of mid-line and below the twelfth rib. There was no discoloration of the skin; there was no tenderness and the swelling faded off into the surrounding tissues without a definite limit or circumscribing outline. An exploratory incision was made. Nothing was found in the subcutaneous fat. When the fascia covering the erector spinæ muscle was incised, the underlying muscle immediately bulged into the incision, as though under considerable tension. The muscle was a pale brown in color, obviously pathologic, but did not have the appearance of a vascular tumor. The diseased portion of the muscle removed was about the size of a horse-chestnut. There has been no further backache, the patient using her back vigorously in the course of her usual duties. While the gross appearance of the specimen removed did not suggest the nature of the trouble the microscopic examination revealed the presence of a hemangioma.

The subject of primary hemangiomas of striated muscles has been thoroughly studied by Dr. John Staige Davis, who, in 1908, reported a series of six cases of his own and 147 cases derived from the literature up to that time. Again in 1930 Doctor Davis added eleven new personal cases, forty-eight cases appearing in the literature since his first article; the total being 212 in all. He believes these tumors for the most part to be congenital in origin, but may be aggravated by trauma; also that the tumors are rarely multiple or malignant. He has found that pain is their chief symptom, this being present in five out of six of his first cases and nine out of eleven of his second series. The pain is apparently due to pressure upon the nerves or to involvement of the nerves in the tumor itself. Pain also is more likely to occur in the long narrow muscles. There may be some functional impairment of the muscles involved, while the tumors are not usually tender, nor need there be discoloration of the overlying skin. While injections, actual cautery, electrolysis, X-ray and radium may be employed, he believes that excision is the best treatment. The majority of the cases have occurred in the muscles of the face, neck and extremities, those of the trunk being much less common.

DR. SEWARD ERDMAN had not considered pain in connection with hemangioma a significant feature until he had a case last winter with pain in the inner aspect of the thigh. Operation was done for lymphangioma. There was no blood in the cut specimen. The patient, a girl of nineteen, had great pain and tenderness over the swelling, which was two inches in diameter. It elevated but did not involve the skin. The mass lay deep in subcutaneous fat. After removing it *en masse* the gross appearance of a cut section resem-

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bled the cellular arrangement in a rubber sponge. There was no blood in it, but only clear fluid and Doctor Erdman assumed it to be angioma. The mother insists on the prenatal origin of this "birth-mark" and recounts while pregnant with this child, she, the mother, was hit on the inner side of the thigh with a pear which caused a black and blue spot and believed at the time this would mark her child, and, sure enough, when the child was born a similarly situated mark was found.

### ANATOMIC TUBERCLE OF THE THUMB

DR. GUILFORD S. DUDLEY presented a man, twenty-eight years of age, a pathologist. He has always been quite well and gives no past history of infection by or susceptibility to tuberculosis. It has been his custom to perform autopsies with bare hands.

On September 30, 1930, he inflicted an incised wound about one quarter of an inch in length upon the skin of the dorsal aspect of his left thumb at the level of the metacarpo-phalangeal articulation. This accident occurred while sectioning a lung extensively diseased by caseous tuberculosis. The wound bled freely, was washed at once with running water, later was bathed with alcohol, and the incident dismissed from his mind. Primary union took place, but by October 5, 1930, a slightly raised erythematous area about three-eighths of an inch in diameter had appeared at the site of the injury. By October 10, 1930, this papular lesion seemed fully formed and showed a very small, superficially ulcerated zone at its central point. An occasional droplet of serous fluid appeared from this ulcer but at no time was there any evidence of active secondary infection. There was no pain, no adenitis, and no systemic symptom. Early in November, 1930, the lesion was treated by two therapeutic exposures to the X-ray. Following the second treatment the area of redness increased slightly in size but, in a few days, returned to its original condition.

On November 25, 1930, the lesion was excised under the pre-operative diagnosis of anatomic tubercle. This was performed under novocaine infiltration anaesthesia and, at the time, it was thought that the excision had been sufficiently wide to assure a complete cure. The skin edges were approximated under moderate tension and primary union took place throughout except at the distal extremity of the scar. At this point there developed an indurated papule about one-eighth of an inch in diameter, and, as in the instance of the first lesion, superficially ulcerated at its central point. After more than two months' unsuccessful treatment with the quartz mercury lamp, the second attempt at operative cure was undertaken. On March 1, 1931, under nitrous-oxide anaesthesia, the recurrent tubercle was excised widely and the defect covered with a full-thickness skin graft taken from the upper arm. This procedure was successful and the region involved is now healed completely.

Histologic examination of the first tubercle showed all the characteristics of an epithelioid tubercle without caseation. In addition, tubercle bacilli were found in a specially stained section. The second specimen also showed typical Langhans giant cells in an epithelioid tubercle without caseation. Tubercle bacilli were not found in this section.

DOCTOR DUDLEY also presented a second patient, a man, who is serving an internship in a hospital. It has been and still is his custom to perform autopsies with bare hands. His past and family history are completely negative for tuberculosis. In September, 1930, solely as a matter of interest, he

## ANATOMIC TUBERCLE OF THE THUMB

had a Mantoux test for tuberculosis performed. This was negative (1-10 dilution).

Early in January, 1931, he inflicted an incised wound of slight extent upon the skin of the dorsal aspect of his left thumb at the level of the metacarpo-phalangeal articulation. This accident occurred while the hand was submerged in tuberculous pus within the thorax in an effort to remove the larynx. The wound bled freely, was washed at once with running water, and tincture of iodine applied. On the following day the wound was re-opened purposely, again allowed to bleed freely, and tincture of iodine repeated. Primary union took place, but within a week, a slightly raised erythematous area almost one-half inch in diameter had appeared at the site of the injury. The lesion was not painful unless traumatized, and there were not systemic symptoms. Three weeks after its appearance the papule was treated by one therapeutic exposure to the X-ray. Two days later two tender, palpably enlarged lymph-nodes were present in the left axilla and the papule superficially ulcerated at its central point. A second X-ray treatment, given one week following the first, seemed again to be followed by increased activity within the local lesion with further enlargement of the axillary nodes. There were no additional constitutional symptoms and X-ray of the chest showed no active or healed tuberculosis. After ten days' rest in the country the axillary nodes subsided and the patient returned to the city for excision of the tubercle.

This procedure was carried out under general anæsthesia by Dr. Carl Burdick. A wide area of skin was removed and the defect covered with a full-thickness skin graft taken from the thigh. This graft is now eight weeks old and is attached firmly. There remains still a small crust on its ulnar side which is to be allowed to detach itself spontaneously.

Histologic examination showed typical Langhans giant cells in an epithelioid tubercle without caseation. Tubercle bacilli were not demonstrated.

These two cases were presented because of the comparative rarity of this manifestation of tuberculosis. It is a disease confined almost exclusively to pathologists, although butchers may develop a bovine type of tubercle. From the point of view of the pathologist, it is not so extremely uncommon. At Bellevue Hospital, where approximately 2,500 autopsies are performed annually (the second largest autopsy service in the world), the Director of Laboratories, Dr. Douglas Symmers, estimates that about twenty-five anatomic tubercles have occurred during the past fifteen years. In this period of time almost 250 internes, resident pathologists, *etc.*, performed autopsies. Thus, as considered by occupation, the infection takes place in somewhat less than one in every ten individuals. The experience gained from these two cases would seem to indicate that the most satisfactory type of treatment is immediate wide excision, with skin grafting to cover the defect.

Doctor Truesdell said that some twenty-five years ago tuberculous infections of wounds of the feet were occasionally seen in children at St. Mary's Hospital for Children. At this time it is probable that many more children ran barefooted than at present, and also that the bacillus of tuberculosis was more generally disseminated in the dirt of the street than now. The usual history was that there had first been some small cut or laceration of the sole of the foot, which had healed as usual but had soon reopened and continued to discharge. Upon incision of this area a localized tuberculous process was found to exist. It was not infrequent that following such a condition in the foot the femoral lymph-nodes became involved in a tuberculous infection.

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### CHRONIC OSTEOMYELITIS OF THE TIBIA

DOCTOR DUDLEY presented a woman, twenty-eight years of age, who was admitted to the Second Surgical Division of Bellevue Hospital, April 30, 1931, complaining of pain and swelling of the right leg. She stated that an enlargement in the region of the right ankle, which seemed to vary in size from time to time, was first noticed about eighteen months before but that not until twelve months later did she suffer from any pain. This pain was situated in the upper third of the leg and accompanying it there appeared a swelling in this region. Since then this swelling has extended progressively to involve practically the entire leg, and motion at the knee-joint has become restricted. Although pain was one of her complaints upon admission, this symptom has not been a prominent feature and is present only upon walking. She gave no history of chills or fever and to her knowledge has had no previous illness which would throw any light upon her present condition. She had been told that a blood test taken elsewhere about six months ago was reported to be negative. She has had but one pregnancy and this terminated spontaneously at two months. She has gained twenty pounds in weight during the past year. There is a diffuse enlargement of the entire right lower leg from the knee to the ankle, particularly marked in the upper half. Many superficial distended venules are seen within the skin on the anterior aspect of the lower half and slight œdema in the region of the ankle. Tenderness to pressure was only of moderate degree, but was more pronounced in the upper half of the leg. Profuse perspiration was present on the entire leg but not on other surfaces of the body. Upon palpation the swelling was of bony, hard consistency and apparently caused by involvement of the tibia. Extension of the leg at the knee-joint was restricted slightly. A few firm lymphatic glands were palpable in both inguinal regions. General physical examination showed a somewhat highly arched palate and slightly unequal pupils which reacted promptly to light and accommodation but no other stigmata of congenital lues. Temperature, pulse and respiration were normal.

The laboratory reported 4,200,000 red blood-cells with 50 per cent. of hæmoglobin and marked central achromia of the cells. White blood-cells were 10,000 with 74 per cent. of polymorphonuclears. Urinalysis was normal (no Bence-Jones protein). The Wassermann reaction was four plus.

The X-ray department reported chronic osteomyelitis of the entire shaft of the tibia with bony sclerosis and periosteal thickening extending to and involving the lower end of the corresponding femur. Radiographic examinations of the remaining long bones, the skull, and the thorax were negative. Since then discussion has centred about the probability of luetic osteoperiostitis and the decision to test the result of anti-luetic treatment has been reached.

She is presented to the society because of the interest attached to the diagnosis.

DR. LEON T. LEWALD said that his impression was that this condition is not osteomyelitis, as he believed it lacked the classical signs, as far as the X-ray was concerned. Involvement of the lower end of the femur is not distinct in the X-ray film, but provided there is such involvement it might well be due to a secondary metastatic lesion. He recalled a similar case in a young woman in whom there was complete swelling of the leg from the knee down. It looked like osteomyelitis but lacked the characteristics of this



#### BACTERIAL SYNERGISM IN DISEASED PROCESSES

disease in regard to pain and suppuration. Biopsy was performed by Dr. William B. Coley and there was some question as to the exact histologic picture. The pathologist said it was a secondary manifestation of a hyper-nephroma. There were some changes which were similar to those in this case which might indicate malignancy. In Baltimore, they have worked out an elaborate chart by which they try to make a positive diagnosis of a given bone tumor. This case was submitted to Doctor Bloodgood's clinic and they reported that it might be a metastatic lesion, but that in their experience secondary growths did not occur below the knee-joint or below the elbow, so the case was still left in doubt. Doctor LeWald said that in his experience secondary metastatic lesions have been seen below the knee and beyond the elbow.

DR. ALLEN O. WHIPPLE asked why lues had been so generally ruled out in this case considering the positive Wassermann, early termination of pregnancy, unequal pupils, lack of leucocytosis and sabre-shaped appearance of the bone.

#### BACTERIAL SYNERGISM IN DISEASED PROCESSES

DR. FRANK L. MELENEY read a paper with the above title for which see page 961.

DR. ALLEN O. WHIPPLE expressed his appreciation of this work done by Doctor Meleney. Aside from the original character of the work itself the value of an investigation of this sort in the development of a bacteriologic research in the general surgical service is great. This is but one example of the help and benefit Doctor Meleney and Doctor Harvey and other workers in that laboratory have been to the Surgical Service of the Presbyterian Hospital. Aside from this individual piece of research, the beneficial effect of having men on the service who are familiar with both the bacteriologic and surgical applications becomes definite, as well as constant, in the study of wound healing and the efforts to improve primary healing in clean wounds, and in the technic of the operating room. Doctor Whipple particularly called attention to the work done in Doctor Meleney's laboratory in regard to the sterilization of catgut and he trusted the Bureau of Standards would in future demand standardization in the sterilization of catgut, which has been very deficient in some of the catgut manufactured.



## BRIEF COMMUNICATIONS

### HEAD OF FIBULA IN HIGH AMPUTATIONS OF LEG

THE remarks of Doctor Marks, in the ANNALS OF SURGERY, May, 1931, vol. xciii, p. 1118, regarding the disposition of the head of the fibula in high amputations of the leg suggest the following practical points:

The removal of the fibular head makes a smooth and conical shaped stump, prevents the secondary pain and disturbance caused by the bone end. It also permits the operator to resect the external popliteal nerve (and inject it with alcohol) at a higher level, thus obviating some of the chances of amputation neuroma and its sequences.

Objections to the removal of the head of the fibula are:

It involves more cutting and a more prolonged operation.

In removing the head the operator may (a) cut into the knee-joint unknowingly, or (b) connect the amputation wound into the knee-joint by opening the bursa about the head of the bone and the interosseous membrane. This bursa may connect by a small passage or be a real accessory pocket of the knee-joint itself.

Should the amputation be elective and aseptic no untoward result may follow. If the amputation is one of urgency, as many *high* amputations are, or if they concern infected tissues, or tissues devitalized which may slough or become infected, the fibula head had best be left *in situ* to guard against infection spreading into the knee-joint. I have seen several such unhappy infections and their sequences after removal of the head of the fibula in septic and potentially septic legs in civil practice and also in those encountered a few years ago in France and Belgium.

KELLOGG SPEED, M.D.,  
Chicago, Illinois.

### THE PRODUCTION OF PEPTIC ULCER AFTER SECTION OF THE GASTRIC NERVE

THIS study was made with the purpose of determining if sectioning the nerves to the stomach in any way modified the development of peptic ulcer produced by a standardized method. It seems reasonable to assume, from what has been written on the function of the vagus nerves and splanchnic nerves in relation to the physiological processes of the stomach, that these nerves might be significant in the development of ulcer, particularly since Durante<sup>3</sup> was able to produce superficial ulcers in rabbits by merely dividing these nerves. Carlson<sup>2</sup> stated that combined section of the vagus nerves and splanchnic nerves results practically in permanent hypotonus of the stomach except under conditions of prolonged starvation. Alvarez<sup>1</sup> has

## GASTRIC NERVE AND PEPTIC ULCER

stated that the vagus nerves carry the stimuli which give rise to psychic secretion of gastric juice and that the splanchnic nerves have an inhibiting action serving to quiet the digestive tract, but that the action of these nerves on the stomach and bowel is generally transient. McCrea and McSwiney<sup>5</sup> have shown that the pylorus derives a portion of its nerve supply from a large branch of the vagus nerve which passes from the region of the cardia to the liver. C. H. Mayo<sup>7</sup> has expressed the belief that both duodenal and gastric ulcers are in all probability accompanied by pylorospasm; he has, therefore, divided this branch of the vagus nerve in cases in which it was evident that the trouble in the stomach was reflex. Hartzell<sup>4</sup> has shown that section of the vagus nerves definitely decreases the acidity of the gastric secretion.

Mann and Williamson<sup>6</sup> described a method for experimental production of peptic ulcer. Briefly, the method consists in severing the duodenum from the pylorus and turning in the end of the duodenum. The first part of the jejunum is sectioned and the distal of the two ends thus made is anastomosed end-to-end to the pylorus. The proximal of the two ends made by sectioning the jejunum is anastomosed side-to-side to the terminal portion of the ileum. By this arrangement all of the duodenal secretions, mixed with the bile and pancreatic juice, are drained far enough from the stomach to prevent regurgitation of the duodenal content into the pyloric region of the stomach. The jejunum, which has been placed in a position similar to that of the normal position of the duodenum, receives all of the gastric secretions, without any possibility of their being mixed with the secretions which are poured into the duodenum. Under such circumstances, the usual site for the formation of ulcer is on the dorsal wall of the jejunum laterally to the right of the long axis of the bowel, 1 centimetre or more distal to the anastomosis.

Three series of experiments were performed in each of which three normal, healthy dogs were selected. All operations were performed under ether anaesthesia and with strictly aseptic technic. Intestinal clamps were not used. Following operation all the dogs received the usual mixed food and in addition milk and syrup.

In the first series of experiments, which was the control for the investigation, duodenal drainage was instituted surgically unmodified by any other procedure. In the second series, preliminary section of the splanchnic nerves was performed. This was done by completely stripping the adventitia from all the vessels in the coeliac axis. After the animals had recovered and had regained any weight which initially they might have lost, duodenal drainage was instituted surgically. In the third series, the vagus nerves were sectioned in a preliminary operation. In order to be sure that the nerves were severed they were cut in the thorax. They were picked up on each side of the oesophagus, just above the diaphragm, and about one centimetre was excised from each. After the animal had recovered from this operation, duodenal drainage was instituted surgically.

## BRIEF COMMUNICATIONS

Briefly, the results were the development of a typical peptic ulcer in each experiment, except in one in which the vagus nerves had been sectioned.

Section of nerves to the stomach did not prevent the development of ulcer in that portion of the intestines which received the gastric content after measures had been taken to drain the duodenal secretion away from that region.

### REFERENCES

- <sup>1</sup> Alvarez, W. C.: The Mechanics of the Digestive Tract. Second Edition, P. B. Hoeber, Inc., 447 pp., New York, 1928.
- <sup>2</sup> Carlson, A. J.: The Control of Hunger in Health and Disease. University of Chicago Press, 319 pp., Chicago, 1916.
- <sup>3</sup> Durante, Luigi: The Trophic Element in the Origin of Gastric Ulcer. Surg., Gynec., and Obstet., vol. xxii, pp. 399-406, April, 1916.
- <sup>4</sup> Hartzell, J. B.: The Effect of Section of the Vagus Nerves on Gastric Acidity. Am. Jour. Physiol., vol. xci, pp. 161-171, December, 1929.
- <sup>5</sup> McCrea, E. D., and McSwiney, B. A.: The Effect of Stimulation of the Vagi in the Pyloric Region of the Stomach. Jour. Physiol., vol. lxi, pp. 28-34, March, 1926.
- <sup>6</sup> Mann, F. C., and Williamson, C. S.: The Experimental Production of Peptic Ulcer. ANNALS OF SURGERY, vol. lxxvii, pp. 409-422, April, 1923.
- <sup>7</sup> Mayo, C. H.: Division of the Vagi for Pylorospasm. ANNALS OF SURGERY, vol. lxxxviii, pp. 669-671, October, 1928.

MEREDITH G. BEAVER, M.D., AND FRANK C. MANN, M.D.,  
of Rochester, Minn.

*From the Division of Experimental Surgery and Pathology  
of The Mayo Foundation.*

## STRANGULATED EPIPLOIC APPENDIX SIMULATING APPENDICITIS

TORSION of the epiploic appendix giving rise to acute abdominal symptoms may be easily confused with acute appendicitis. In more than 50 per cent. of the cases reviewed by Johansson, the diagnosis of acute appendicitis was made; in no case was the correct diagnosis made before operation. The case reported here is of interest because of the rarity of the condition, and because it is the result of true torsion, the meso-appendix being involved secondarily.

A woman, aged thirty-three years, was admitted to hospital June 6, 1931, because of pain in the right lower quadrant of the abdomen. The pain had not been severe as a rule, and was relieved by rest in bed for a few hours. She had never had any acute attacks of abdominal pain associated with nausea or vomiting. She had been constipated and occasionally some pain in the right side was associated with defecation. A diagnosis of chronic recurrent appendicitis was made.

June 9, 1931, the abdomen was explored. The uterus and adnexa were normal. The gall-bladder felt normal and did not contain stones. The appendix, however, was long and was attached to a tumor about two centimetres in diameter low in the pelvis. The tumor was the result of a twisted epiploic appendix of the sigmoid; circulation to it was completely cut off. The tumor was attached to the sigmoid by a thin pedicle about one and one-quarter centimetres long and was removed without difficulty. The appendix also was removed.

## STRANGULATED EPIPIOIC APPENDICITIS

The appendix was 6 by 0.6 centimetres. The serosa was slightly injected, otherwise it did not show evidence of infection. The tumor attached to the meso-appendix measured 2 by 1.8 centimetres. It was lobulated and multilocular, and contained clear fluid. The diagnosis of a strangulated epiploic appendage was verified in the laboratories of The Mayo Clinic. Recovery was uneventful and the patient left the hospital on the twelfth post-operative day.

Lesions arising in the epiploic appendix are generally considered due to some interference with the blood supply. Strangulation may take place slowly or suddenly and is usually associated with the formation of cysts. Klingenstein has noted that these cysts may become as large as about 5 centimetres in diameter; they may not become infected, but there is frequently considerable inflammatory reaction, which results in adhesions to neighboring organs and acute abdominal symptoms may arise.

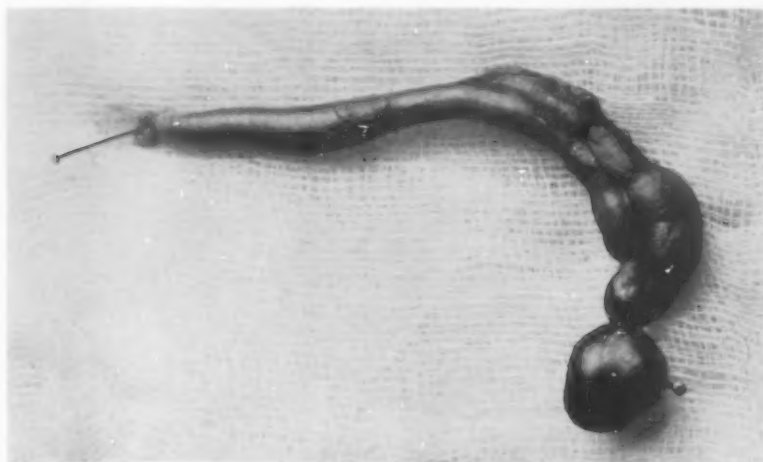


FIG. 1.—Strangulated epiploic appendage attached to the meso-appendix.

Klingenstein, in 1924, reviewed from the literature fifty-three cases of which twenty were due to torsion and retained attachment to the colon, twelve were loose bodies within the peritoneal cavity and twenty were associated with hernia. The first two groups are of especial significance.

The term epiploic appendix originated from Meckel. The appendages which consist of finger-like pouches of peritoneum containing varying amounts of fat are found along the whole of the large intestine except the rectum; they are more numerous in the transverse and pelvic colon. The various courts of the large intestine do not enter into their formation. Their number varies but Johansson quoted Robinson as having noted about 100.

In the cases in which hernia is a complication the interference with circulation is easily understood. However, it is believed that in many of these cases torsion occurs within the hernial sac. The epiploic appendix may become distended with fluid. The cystic masses may become infected and give rise to symptoms simulating intestinal obstruction. Operation is usually performed for strangulated hernia and the true condition is discovered.

## BRIEF COMMUNICATIONS

In the cases generally referred to under the term intra-abdominal torsion, it is not so easy to understand the interference with circulation. Payr has suggested that disproportion between the artery and vein is the cause. Occasionally the epiploic appendix has been found twisted one or more times on its pedicle. Necrosis of its pedicle may occur and the appendix drops off, and remains a foreign body in the peritoneal cavity. There are twelve of these cases on record. These cases, however, are not of especial clinical interest; the condition is usually found during laparotomy for some other condition.

Two other types of torsion may occur which are of more clinical significance. Gradual interference with the blood supply may result in a chronic inflammatory mass and this may become attached to the omentum or as in the case reported the appendix forms a potential means of mechanical intestinal obstruction.

In still another type the epiploic appendix becomes distended with fluid but retains its attachment to the colon. Cystic masses about 5 centimetres in diameter have been reported as retaining their attachment to the colon by long pedicles. These may or may not become inflamed. Sometimes most acute abdominal symptoms may arise necessitating immediate operation.

The diagnosis is extremely difficult. In none of the twenty cases of torsion necessitating immediate operation, reviewed by Johansson was the diagnosis made pre-operatively. Appendicitis is the most common diagnosis.

BEAN M. PALMER, M.D., and  
J. E. HARDMAN, M.D.,  
*Youngstown, Ohio.*

## BIBLIOGRAPHY

- <sup>1</sup> Hunt, V. C.: Torsion of Appendices Epiploicæ. *ANNALS OF SURGERY*, vol. lxi, pp. 31-46, January, 1919.
- <sup>2</sup> Johansson, Sven: Torsion of Appendices Epiploicæ as a Cause of Disease. *Acta chir. Scand.*, vol. lxi, pp. 205-212, 1926.
- <sup>3</sup> Klingenstein, Percy: Some Phases of the Pathology of the Appendices Epiploicæ. *Surg., Gynec., and Obstet.*, vol. xxxviii, pp. 376-382, March, 1924.

## EDITORIAL ADDRESS

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Remittances for Subscriptions and Advertising and all business communications should be addressed to the

**ANNALS OF SURGERY**  
227-231 South Sixth Street  
Philadelphia, Penna.



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